INDEX TO

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INDEX

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ARTICLES

COMMUNICATIONS

EDITORIALS

ENGINEERING SPECIALTIES

LAYING OUT PROBLEMS

PARAGRAPHS

TECHNICAL PUBLICATIONS

THE BOILER MAKER

JANUARY, 1912

Strain Measurements of Some Steam Boilers Under Hydrostatic Pressures*

BY JAMES E. HOWARD[1]

The object of these tests is to ascertain the condition of the metal of the shell and other parts of two horizontal tubular steam boilers which had been in use for a term of service of unusual length; and in addition thereto to acquire information on constructive details by means of measured strains.

The boilers were contributed for investigative purposes by the treasurer of the Kendall Manufacturing Company, Providence, R. I., the late Nicholas Sheldon, Esq. They were of early manufacture and from their remarkable history and present condition were of special value for these tests. They were made by the Whittier Machine Company, Boston, Mass., using "Benzon" brand of steel, and were put into service March, 1881. They were in continuous service for a period of twenty-seven years, during which time, as Mr. Sheldon wrote, "no repairs were required; in fact, not one cent has been spent upon them."

They consisted of five-course boilers, two sheets to a course, having the following general dimensions:

Diameter	72 inches
Length, over dry sheet	16 feet
Thickness of shell	⅜ inch
Thickness of heads	½ inch
Number of tubes	140
Diameter of tubes	3 inches
Length of tubes	15 feet
Diameter of dome	2 feet 6 inches

Longitudinal seams, double-riveted lap joints, ¾-inch rivets, 2-inch pitch, punched holes, rows 2⅛ inches apart, rivets staggered.

Girth seam, ¾-inch rivets, 2⅛-inch pitch.

Heads stayed, each, with 14 braces.

Cast-iron manhole frames and safety-valve nozzle.

Supported by lugs, three on a side.

The feed water came from the Pawtucket River.

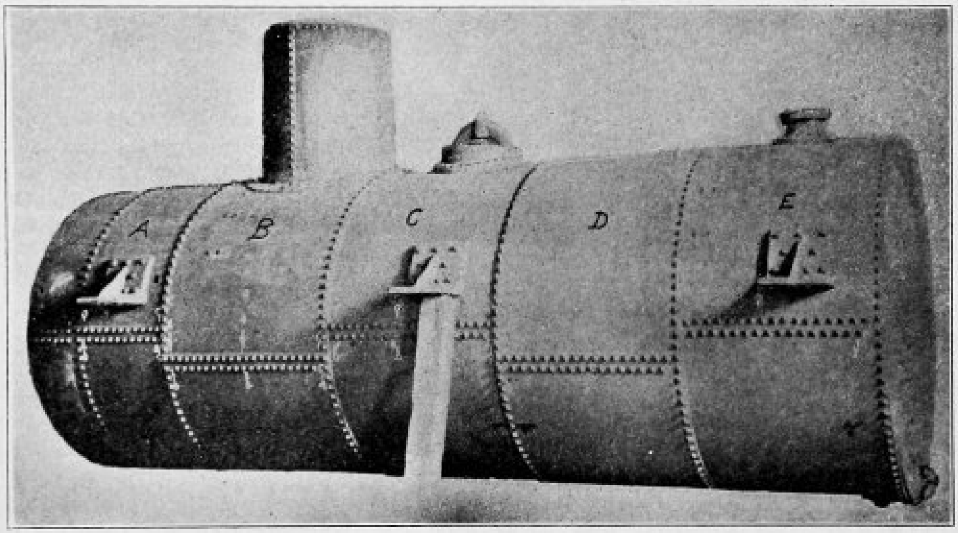

FIG. 1.—STEAM BOILER NO. 4084 BEFORE TESTING

The hydrostatic tests were made at the W. H. Hick's Boiler Works, Providence. Mr. Francis B. Allen, vice-president of the Hartford Steam Boiler Inspection & Insurance Company, assisted and advised with the writer in conducting them. The boilers will be designated by the numbers 4084 and 4092, under which they were carried on the books of the Hartford company.

The tests began with strain measurements upon different parts of the boilers as they were subjected to successive increments of hydrostatic pressures. The results of this portion of the inquiry are now available and herewith presented. Much remains to be done in the other direction of testing, pertaining to the physical properties of the materials.

Measurements of the deformations of engineering structures, whether steam boilers, bridges or buildings, may be expected to develop information of a kind not attainable in the tests of the component parts of those structures. A compara-

* From a paper read before the American Society of Mechanical Engineers, New York, December, 1911.

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tively new field of inquiry is presented in the tests of structures over the tests of the materials thereof. The effects of combined stresses may readily be studied in this manner.

No more simple type of boiler could be chosen than the plain, horizontal, tubular boiler of these tests, yet it will be seen from the results that complexity of strains and stresses are found in most parts of the shell. In comparatively few

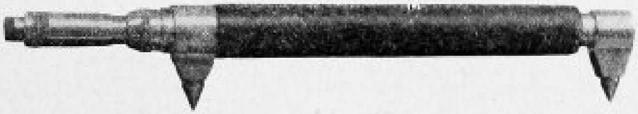


FIG. 2.—10-INCH HOWARD STRAIN GAGE

places are tangential strains displayed corresponding in magnitude to those which would be expected in a thin cylindrical shell subjected to a given interior pressure.

Ascertaining the deformations by the method of measured strains, locally determined, consists of establishing gaged lengths on different parts of the boiler and then measuring them initially and at intervals as the hydrostatic pressures are successively applied and released.

Gaged lengths of 10 inches each were used in the examination of these boilers. Their extremities were defined by small drilled and reamed holes. The holes are about 0.05 inch in

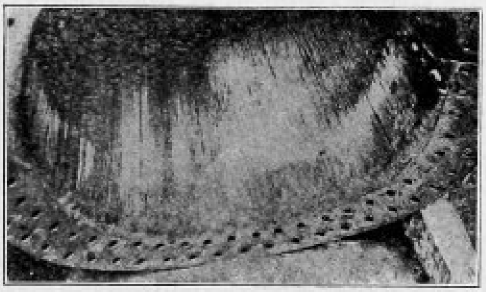


FIG. 3.—INTERIOR OF DOME SHOWING LINE ALONG WHICH SCALE WAS DISTURBED AFTER PRESSURE OF 266 POUNDS ON SHELL

diameter by, say, 0.10 inch deep, and reamed to a conical shape. The angle of the reamer is 65 degrees, and the distance across the hole at the surface of the shell sheet about 0.08 inch.

Such holes carefully made, in metal surfaces, are capable of centering with considerable precision the contact points of the

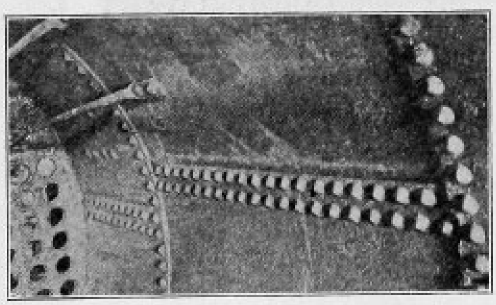


FIG. 4.—INTERIOR VIEW OF BOILER NO. 4084 AFTER 295 POUNDS PRESSURE, SHOWING SCALE DISTURBED IN VICINITY OF LONGITUDINAL SEAM

micrometer strain gage. The strain gage is used as a transfer instrument to compare the gaged lengths on the work with a corresponding length on a standard reference bar.

Fig. 2 shows the 10-inch strain gage used on these tests. It consists of two principal parts, an outer tube and an inner stem, which are telescopic, working on ball bearings. Each part carries a conical contact point for centering the instrument on the reference bar and on the work. A screw micrometer measures the length of the instrument when in position.

The conical contact points of the strain gage have an angle of 55 degrees. This difference of 10 degrees between the reamed hole in the boiler shell and the points of the gage

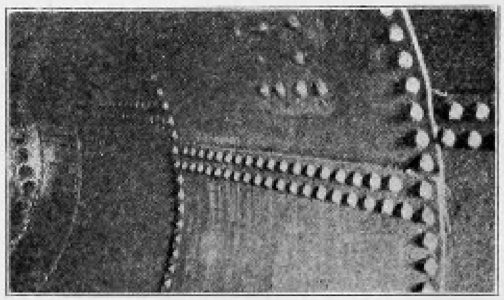


FIG. 5.—INTERIOR VIEW OF BOILER NO. 4084 AFTER 295 POUNDS PRESSURE, SHOWING SCALE DISTURBED IN VICINITY OF LONGITUDINAL SEAM AND UNDER SUPPORTING LUG

secures contact at a short distance below the surface of the shell. Ordinarily the reference holes are safe against accidental injury, due to their position.

As to the degree of precision attained with the strain gage, in the hands of skilled manipulators and under favorable conditions, such as were experienced with these boilers, it is believed the readings are generally reliable to one ten-thousandth of an inch. This strain corresponds to a stress of 300 pounds per square inch on a 10-inch gaged length, using a modulus of elasticity of 30,000,000 pounds. Fig. 1 shows boiler No. 4084. Both boilers were of the same dimensions except at the dry sheets. When on their settings, boiler No. 4084 was on the right, boiler No. 4092 on the left side. This view shows the locations of some of the gaged lengths which were established on this boiler, taken in both tangential and longitudinal directions.

A more comprehensive series of lengths was established on boiler No. 4092, and the general discussion of the results of

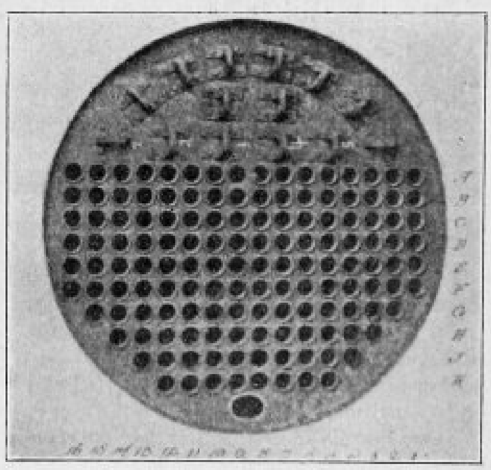


FIG. 6.—INSIDE OF REAR HEAD, BOILER NO. 4084, AFTER 295 POUNDS PRESSURE

the strain measurements will be given in connection with the test of that boiler.

In the test of No. 4084 greater strains were displayed in the vicinity of the dome and the manhole frame than at other parts of the shell. This resulted, as would clearly be expected, in the early failure of the boiler at those places.

Actual rupture of the dome was not accomplished, but leakage along its single-riveted longitudinal seam became so great at 266 pounds pressure that it was necessary to remove the dome and patch the shell in order to reach higher pressures with the pump available.

At 270 pounds pressure the cast iron manhole frame fractured across the middle of its length. Another patch was then put on the shell covering the manhole.

The test was again resumed when at 295 pounds pressure the rupture of three braces of the front head occurred. The test was then discontinued and the boiler dismantled.

The strain measurements made in the test of No. 4084 were of the same general order as those subsequently made in the

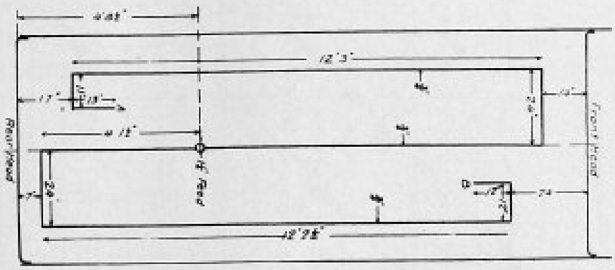


FIG. 7.—LAYOUT OF FEED-PIPES

test of the second boiler and the results were, for the most part, quite similar.

A feature, however, in the test of the first was absent or obscure in that of the second. There was a progressive difference in the extensibility taken across the longitudinal seams

TABLE 1.—TANGENTIAL EXTENSIONS OF THE SEAMS, BOILER NO. 4,084

	Course.			
PRESSURES.	B.	C.	D.	E.
210	0.0166	0.0121	0.0099	0.0084
240	0.0241	0.0171	0.0138	0.0121
270	0.0341	0.0241	0.0212	0.0187

of the several courses in passing from the front to the rear end of the boiler.

the boiler. If such was the case it would aid in explaining the greater slip of the forward seams.

Hydrostatic pressures on the exterior surfaces of the tubes necessarily extend them in length. The amount of the extension appears to depend upon their position with reference to their proximity to the shell. Tubes adjacent to the shell extended less than those at the middle of the rows, a restraining influence from the shell appearing to affect the outer ones.

The results in Table 2 were obtained by measuring the tubes over their full length.

Practically no leakage occurred about the tubes throughout the test of this boiler. A slight leakage took place at two tubes at 120 pounds pressure, but soon ceased and was not renewed during the remainder of the test. The girth seams remained tight up to 210 pounds pressure, and then showed only small leaks which were not materially increased under the higher pressures.

Leakage at the longitudinal seams began at 120 pounds pressure and increased as higher pressures were applied. The leakage became general at these seams with 180 pounds pressure on the boiler, but at this time the slip of the joints had become a pronounced feature of the case, which necessarily disturbed the calking.

TABLE 2.—EXTENSION OF TUBES: BOILER NO. 4,084

	Third Row.		Seventh Row.	
PRESSURES.	Next Shell.	Middle of Row.	Next Shell.	Middle of Row.
210	0.0110	0.0162	0.0077	0.0167
240	0.0128	0.0184	0.0086	0.0189
270	0.0142	0.0210	0.0099	0.0210

Upon removal of the dome, evidence of overstraining was found at its base next the flanged portion. The scale had been disturbed on the inside on the line and in the vicinity of the upper element of the boiler, as shown in Fig. 3. Near the flange the scale was disturbed in oblique, shearing directions, which changed to longitudinal and then tangential directions a little farther up the dome.

Figs. 4 and 5 are interior views of the boiler illustrating the manner in which the scale was disturbed during the test in the vicinity of the longitudinal seams and under one of the lugs.

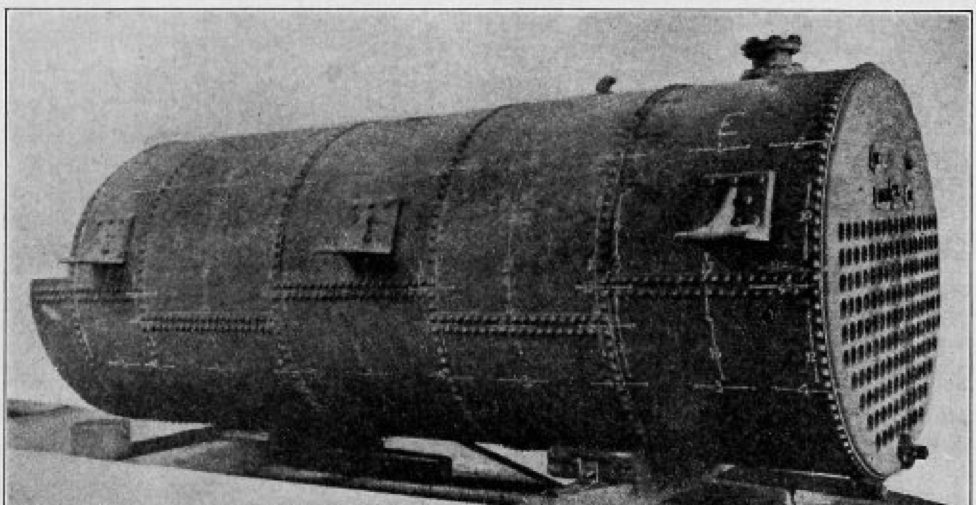


FIG. 8.—STEAM BOILER NO. 4092, DOME AND MANHOLE FRAME REMOVED PREPARATORY TO TESTING. HEADS STRENGTHENED WITH SIX THROUGH BRACES

The tangential extensions of the seams, at the middle of their lengths, were as shown in Table 1.

While these seams were not directly exposed to the heated gases over the grate, nevertheless it seems probable that a wider range of thermal conditions prevailed in the vicinity of the seams at the front end over those at the rear end of

Struts were used under the middle lugs and supported a part of the weight of the boiler during the test. They probably intensified the stresses in the shell in that vicinity. The interior surface of the shell and also the heads were found in good condition. Fig. 6 shows the appearance of the inside of the rear head.

A series of six photographs showed the appearance of the exterior surfaces of the tubes. The system of lettering and numbering the horizontal and the vertical rows is indicated in Fig. 6. The layout of the feed pipes appears on Fig. 7.

Tubes in the horizontal row marked *D*, the fourth in the boiler from the top, Fig. 6, had a deposit on the rear third of their length, and also a slight deposit on the front ends. On some of the lower rows the deposit was thicker. In general, the deposit was greatest in the lower rows of tubes and on those farthest from the shell, being confined chiefly to the rear quarter or half of their lengths. The lower rows of tubes, at the front end of the boiler, had a deposit on them. The surfaces of the upper row and the side rows were clean without deposit.

Material collected from the bottom of the boiler at the front and rear ends had the following chemical composition:

Deposit from Front End of Boiler.	Percent.
Loss at 105 degrees cent.	8.70
Loss on ignition	26.00
SO_3	4.10
Silica	21.60
$Fe_2O_3 + Al_2O_3$	25.40
Lime	5.30
Magnesia	13.10
Copper oxide (about)	0.25
CO_2	slight amount
Chlorides	trace

Deposit from Rear End of Boiler.	Percent.
Loss at 105 deg. cent.	9.65
Loss on ignition	23.85
SO_3	trace
Silica	27.60
$Fe_2O_3 + Al_2O_3$	24.80
Lime	9.60
Magnesia	12.70
Copper oxide (about)	0.25
Chlorides	trace
Carbonates	small amount

Prior to testing boiler No. 4092, it was stripped of its dome and manhole frame and the shell patched at those places. The heads were strengthened by means of six 1¼-inch braces extending from head to head. The cast iron safety valve nozzle was allowed to remain in place, but was eventually replaced by a soft patch, after 300 pounds pressure had been applied and released. The distortion of the shell under the flange of the nozzle caused leaks impracticable to calk.

Fig. 8 shows the boiler when about ready for the hydrostatic test. It was supported on two wooden shoes sawed to fit the curvature of the shell, in lieu of the blocking shown in the illustration.

The gaged lengths were established on the right side of the boiler. There were 165 gaged lengths used in the principal series of observations, on which some 3,300 readings were taken.

The general results of the strain measurements have been plotted on a series of ten diagrams, Figs. 9 to 18, inclusive. For the purpose of furnishing a convenient basis of comparison, in judging the behavior of the boiler at different parts and under different pressures, heavy lines have been drawn on each diagram which indicate strains corresponding to those which would be displayed by the sheets under direct tensile stresses, using a modulus of elasticity of 30,000,000 pounds per square inch. Plotted curves, which are steeper than the modulus of elasticity reference line, indicate places on the boiler having greater rigidity than normal to the plain sheets; while flatter curves indicate greater extensibility than pertains to the plain metal.

TABLE 3.—COMPUTED STRESSES ON THE SHELL SHEETS, BOILER NO. 4,092

Boiler Pressure, Lbs. Per Square Inch.	Stress on ⅜-Inch Shell, Lbs. Per Square Inch.	Strain on Gaged Length of 10 Inches.
30	2,880	0.0010
60	5,760	0.0019
90	8,640	0.0029
120	11,520	0.0038
150	14,400	0.0048
180	17,280	0.0058
210	20,160	0.0067
240	23,040	0.0077
270	25,920	0.0086
300	28,800	0.0096

Tangential rigidity above the normal was displayed in the vicinity of the girth seams, while the gaged lengths taken across the longitudinal seams at the middle of the length of courses showed a much lower degree of rigidity than common to the plain sheet. Zones of greater extension than normal were also found in the vicinity of the manhole and dome.

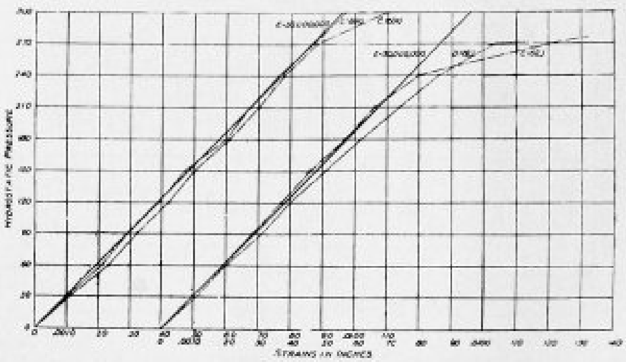


FIG. 9.—CURVES OF TANGENTIAL EXTENSION, SOLID SHEETS, AT MIDDLE OF LENGTH OF COURSES *C* AND *D*, RIGHT AND LEFT SIDES OF BOILER

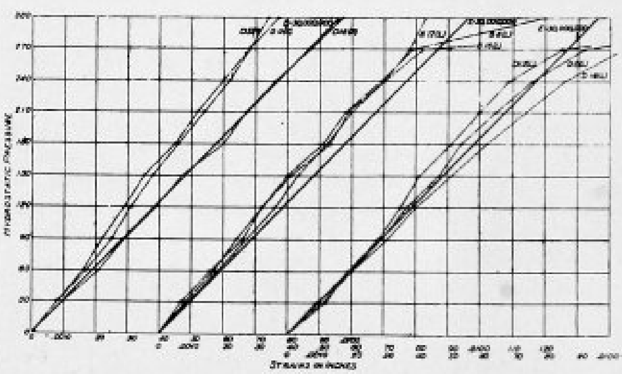


FIG. 10.—CURVES OF TANGENTIAL EXTENSION, SOLID SHEETS, NEAR GIRTH SEAMS AND AT MIDDLE OF LENGTH OF COURSES

Flattening of the curves representing the solid sheets necessarily accompanied those pressures, which caused a tensile stress on the shell in excess of its elastic limit.

Table 3 shows the computed stresses on the shell sheets, considering only tangential stresses as acting, and the strains which should be developed on a gaged length of 10 inches, using a modulus of elasticity of 30,000,000 pounds, the interior diameter of the boiler being 72 inches.

Referring now to the plotted results, Fig. 9 shows the tangential extensions of sheets *C* and *D* on the right and left sides of the boiler respectively, taken at the middle of the lengths of the courses. Gaged length *D*-18, on the right side of the boiler, was located above the longitudinal seam, while *C*-16, on the right side, was located below the longitudinal seam.

The tangential extensions of each of these gaged lengths closely follow the modulus of elasticity comparison curve. The departure of *D*-18 from this line does not exceed 0.0002 inch at any pressure, and coincides with it at several pressures.

The extensions displayed by the gaged lengths on the opposite side of the boiler agreed fairly well with the modulus of elasticity reference line also, but not so closely as the results found on the right side, while rapid extension took place one increment of pressure earlier than on the right side. So close a correspondence between the measured and the computed strains as shown on this diagram did not, however, characterize many places on the shell. Commonly there were modifying influences which distrubed the normal display of elastic extensions of the metal.

Fig. 10 shows that the tangential strains near the girth seams *D*-5 and *D*-9 were less than at the middle of the course. In general this behavior was shown in the other courses, but an exception was found on the left side of the shell. In course *D* was found the feedwater connection, which probably did not have much influence on the behavior of this course while under pressure. Course *E* had the cast iron safety valve nozzle riveted to it, which did seem to have an influence on the tangential extension of the steel, permitting greater extension than normal.

The extension of course *A* at the edge over the front head was less than at the opposite edge. Gaged lengths *B*-52 and *B*-57 showed the influence of the overlapping metal of the patch, as well as that of the girth seams. The extension at these two places was less than normal.

At the side of the manhole patch *C*-58 there was found diminished rigidity in the shell. The weakness of this single-riveted patch was apparent in the measurements from the

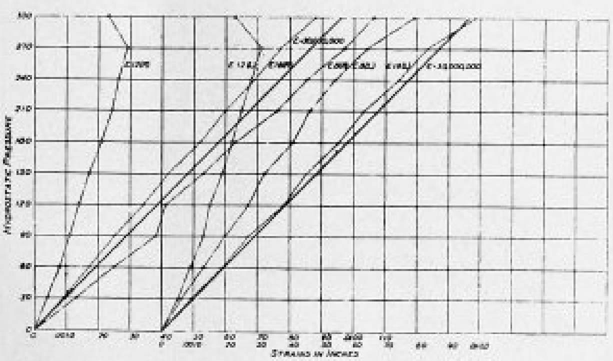


FIG. 11.—CURVES OF TANGENTIAL EXTENSION, SOLID SHEETS, END COURSE *E*, NEAR REAR HEAD, GIRTH SEAM, AND MIDDLE OF LENGTH OF COURSE

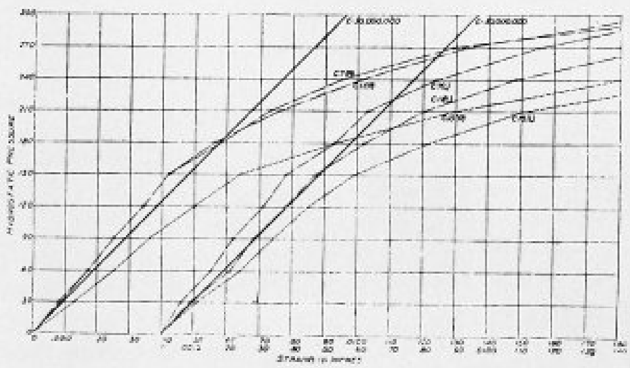


FIG. 13.—CURVES OF TANGENTIAL EXTENSION, ACROSS LONGITUDINAL SEAMS, AT MIDDLE OF LENGTH OF COURSE *C*, AND AT EDGES, RIGHT AND LEFT SIDES OF BOILER

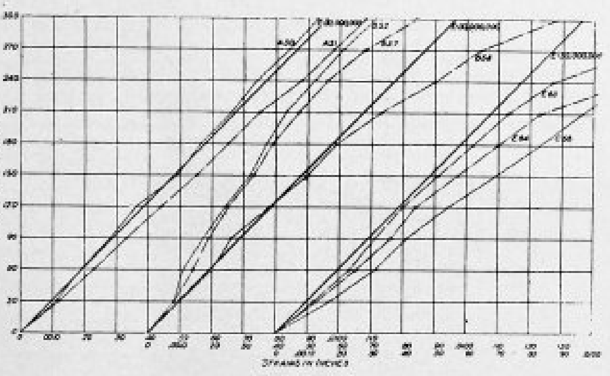


FIG. 12.—CURVES OF TANGENTIAL EXTENSION, TOP OF BOILER, NEAR FRONT HEAD, GIRTH SEAMS, DOME AND MANHOLE PATCHES AND SAFETY-VALVE NOZZLE

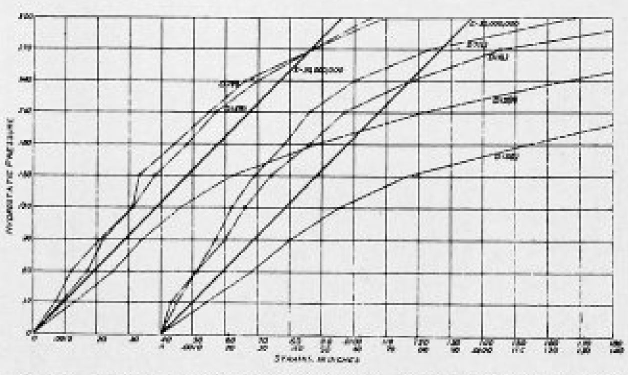


FIG. 14.—CURVES OF TANGENTIAL EXTENSION, ACROSS LONGITUDINAL SEAMS, AT MIDDLE OF LENGTH OF COURSE *D*, AND AT EDGES, RIGHT AND LEFT SIDES OF BOILER

boiler in course *B*, where substantially the same rigidity was displayed at the middle as at the edges of the course.

In the third group of curves on this diagram, however, the extension of *D*-16 taken at the middle of the course is seen to be greater than at *D*-8 and *D*-12, curves representing the edges.

There is a marked difference in the tangential extension of the two edges of the end courses of the boiler, due to the influence of the heads in supporting the shells. Fig. 11 shows the greater rigidity of gaged lengths *E*-12, which are taken nearly over the rear head, than at the other places, which were measured on this course.

In regard to the top of the boiler there were many disturbing factors present, as indicated by Fig. 12. The first course is a short one, with the front head to stiffen one edge. Then came the dome in the original construction on course *B*, which was patched, and the patch double-riveted, using the rivet holes that were made for securing the flange of the dome to the shell. Course *C* had the manhole patch, a single riveted one, using the holes made for securing the manhole frame to earliest pressures which were applied to the boiler. Conditions about the safety valve nozzle did not seem fully to compensate for this opening in the shell, as shown by the extensions on gaged lengths *E*-63 and *E*-64.

Referring next to the behavior of the shell at the seams, Fig. 13 shows two groups of curves of three lines each which represent the tangential extensions on gaged lengths established on course *C* taken across the longitudinal seam at the middle and at the edges of the course.

Curves *C*-7 and *C*-11, representing the extension at the edges of the course on the right side of the boiler, coincide in places and show but slight divergence where they depart most from the same line; that is, they indicate that uniform behavior was displayed at the opposite edges of this course. Each deflect rapidly under pressure above 150 pounds per square inch, corresponding to a tensile stress of 14,400 pounds per square inch on the solid sheet.

At the middle of the length of the course, curve *C*-15 showed an increase in the rate of extension at the abovementioned pressure, and for each succeeding pressure a greater extension than that witnessed at the edges. Necessarily, variations in the tangential extensions at different parts of the length of a seam would cause variations in the stresses of the solid metal of the shell in those localities.

In the case of a three-course boiler with one sheet to a course, as found in current construction, it would seem that a double-riveted lap joint might occasion an excessive stress in the solid sheet abreast the end of the seam under certain pressures.

In the present test the longitudinal seams, being only three rivet pitches apart, furnish a line from front to rear of the boiler across which the extensions are greater than those which are displayed by the solid sheets.

Fig. 14 shows results corresponding to those of Fig. 13, but pertaining to *D*, the next course of the boiler. The results are about the same on each, the maximum tangential extensions being displayed at the middle of the length of the seams.

Fig. 15 shows the extension of end course *A*, across the longitudinal seams on either side of the boiler, and also the extension of the solid sheet near the girth rivets of the front head. The divergent curves of this diagram indicate how differently in degree the metal is strained at the several gaged lengths of this narrow course. There seems, however, no lack of consistency in the behavior of the metal. The strains were relatively such as would be expected under the conditions present in this part of the boiler.

The strains in course *E*, at the rear end of the boiler, are shown in Fig. 16, where the behavior of the shell was found to be similar to that at the front end. Notwithstanding the fact that the results appear consistent and the relations between the different parts of the boiler harmonious, attention is attracted by the variableness of the strains as they are found developed, according to the position of the measured lengths. The degree of variability witnessed in this type of boiler, which is certainly one of plain form, is such as to excite speculative interest in more complicated types.

The results of the diagrams, Figs. 9-18, refer to the total extensions of the gaged lengths, that is, they include the elastic extensions and the permanent sets when sets have occurred. The curves in Fig. 17 were plotted for the purpose of showing the elastic extensions only, or what is equivalent to the same, the resilience of the shell taken across the longitudinal seam of course *D*, right side. The greater resilience of gaged length *D*-15, which was located across the longitudinal seam at the middle of its length, over the amount called for by the modulus of elasticity curve will be noted. This might be taken to indicate an intensity of stress above the normal in the shell in that vicinity, or it may mean that bending and shearing stresses at the seam in addition to tensile stresses on the sheets modified the results.

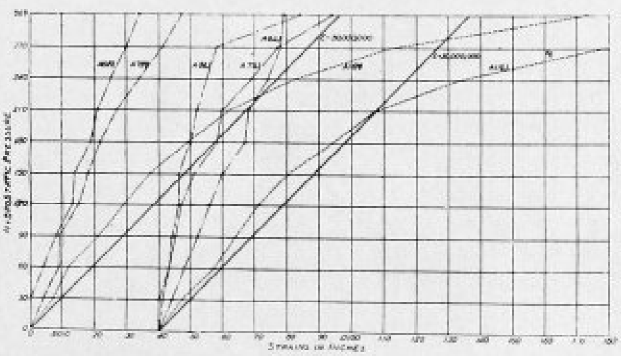


FIG. 15.—CURVES OF TANGENTIAL EXTENSION, ACROSS LONGITUDINAL SEAMS AND SOLID SHEETS, END COURSE *A*; EXTENSIONS NEAR FRONT AND GIRTH SEAMS

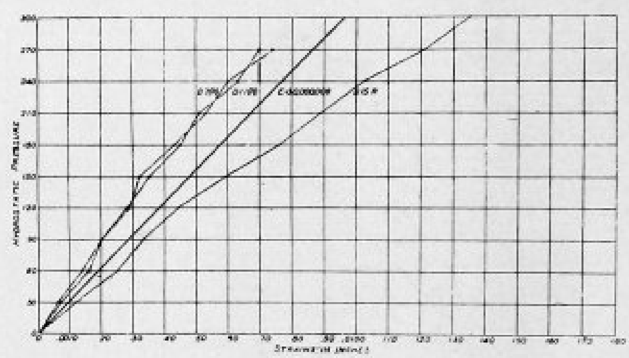


FIG. 17.—CURVES OF TANGENTIAL RESILIENCE, ACROSS LONGITUDINAL SEAM, COURSE *D*, RIGHT SIDE OF BOILER, AT MIDDLE OF COURSE AND NEAR GIRTH SEAMS

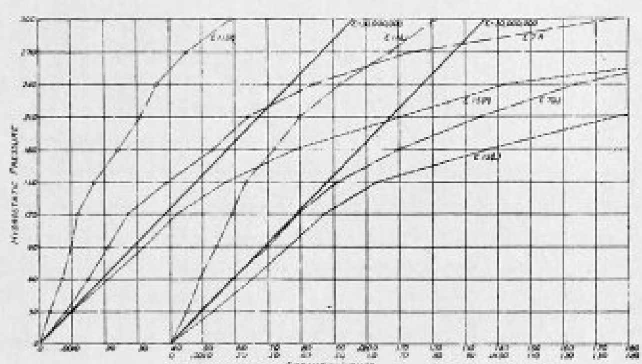


FIG. 16.—CURVES OF TANGENTIAL EXTENSION, ACROSS LONGITUDINAL SEAMS, END COURSE *E*; EXTENSIONS NEAR REAR HEAD AND GIRTH SEAM AND MIDDLE OF LENGTH OF COURSE

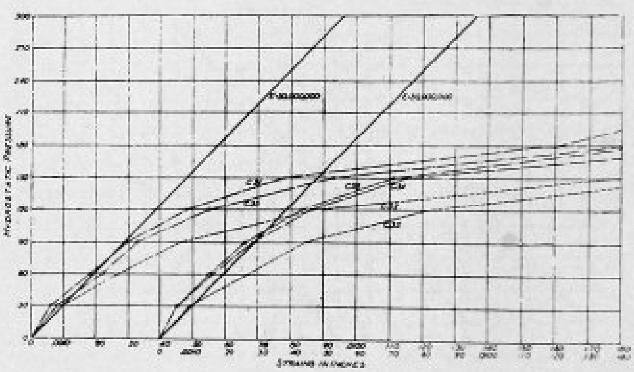


FIG. 18.—CURVES OF TANGENTIAL EXTENSION, HAND-RIVETED SECTION, COURSE *C*, TOP OF BOILER

The interior pressure on the boiler was increased from 300 pounds, the highest indicated on the diagrams, to 335 pounds, under which latter pressure rupture of the manhole patch occurred. Three of the rivets were sheared by the tangential stress of the shell, followed, apparently, by the fracture of other rivets by tension on the stems, which pulled off the heads and finally tore the shell longitudinally along its upper element, starting this fracture at a rivet hole of the manhole opening. Fig. 21 shows the appearance of this fracture.

The shell was repaired by cutting out a portion of course *C*, across the top of the boiler and putting in a section the full length of the course and about 3 feet wide, measured on the arc. This new section was double-riveted to the shell at its longitudinal seams. The rivets were 13/16 inch in diameter and had a pitch of 2.87 inches. The rows were 1.53 inches apart, with rivets staggered, which were, of course, hand-driven. The points of the rivets were hammered down to conical shape, low in height and with thin edges. In this respect they were less substantial than the points of the original machine-driven rivets of the seams.

The hand-driven rivets would not be expected to hold the calking as well as the machine-driven rivets by reason of the difference in their points, and the test showed that such weakness was the case.

Diagram, Fig. 18, shows the behavior of the seams of this new section of course *C*. The flatness of the curves indicate how early these new seams began to display rapid extension, and with so decided a movement the calking was soon disturbed and copious leaks started. At the time of presenting these notes no higher pressure has been reached than the rupturing of one of 335 pounds previously mentioned.

The strain measurements thus far described were those which were observed on tangential gaged lengths. In addition to this there were longitudinal gaged lengths laid off on the shell and measured.

In a plain cylindrical shell the tangential extension of the metal would necessarily be attended with a definite amount of longitudinal contraction, eliminating the effect of pressures on the head. The conditions, however, which are present in steam boiler construction will generally prevent realizing the longitudinal strains which would be looked for in a plain sheet.

In the present test there were parts of the boiler nearly free from longitudinal strains, while there were other places in which the strains were reversed, and longitudinal extension shown instead of longitudinal contraction.

In order to determine whether the action immediately at the girth seams was represented by the 10-inch gaged lengths which spanned them symmetrically, other gaged lengths were established on the shell not indicated on the diagrams here-

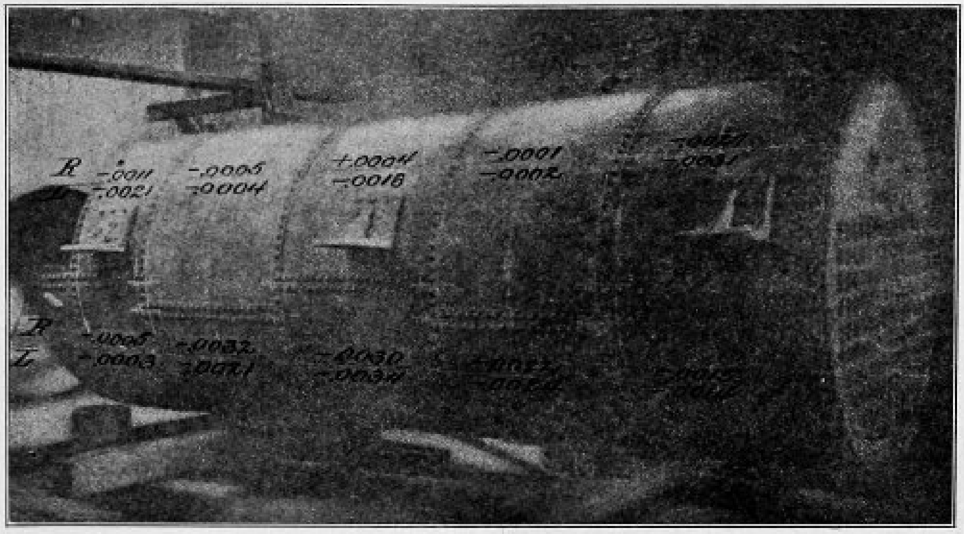


FIG. 19.—LONGITUDINAL STRAINS ON SOLID SHEETS AT MIDDLE OF LENGTH OF COURSES, AT 270 POUNDS PRESSURE PER SQUARE INCH, RIGHT AND LEFT SIDES OF THE BOILER.

Minus signs indicate longitudinal contraction; plus signs longitudinal extension.

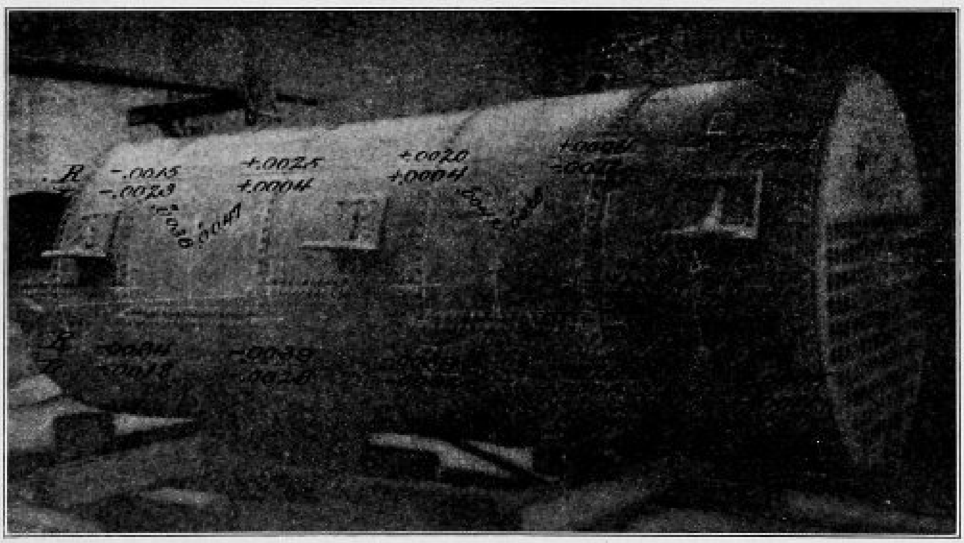


FIG. 20.—LONGITUDINAL STRAINS, ACROSS GIRTH SEAMS, AT 270 POUNDS PRESSURE PER SQUARE INCH, RIGHT AND LEFT SIDES OF THE BOILER; ALSO STRAINS ON DIAGONAL GAGED LENGTHS OF COURSES *B* AND *D*

Minus signs indicate longitudinal contraction; plus signs longitudinal extension.

with presented. These were in pairs, one being wholly on the solid sheet, the other just stepping on to the adjacent course. The observations on these gaged lengths led to the same results, however, as found on those which symmetrically spanned the seam.

The results of these observations showed that along the lower quarter of the boiler the longitudinal strains were contractions; while along the upper quarter they were in part contractions, and in part extensions. The strains observed at 270 pounds pressure are entered on two lightly printed photographs, Figs. 19 and 20. In Fig. 19 are shown the strains which were measured on gaged lengths 1 and 3, taken on the solid sheets at the middle of the lengths of the courses. In Fig. 20 are shown the strains which were

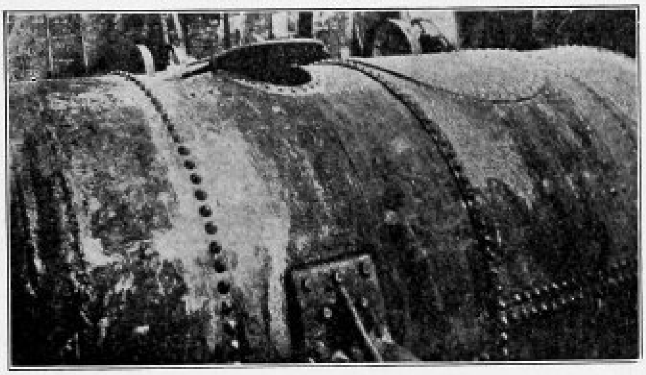


FIG. 21.—MANHOLE PATCH AFTER RUPTURE; MAXIMUM PRESSURE ON SHELL 335 POUNDS PER SQUARE INCH

measured on gaged lengths 2 and 4, taken across the girth seams. Minus signs before the figures indicate contractions, while plus signs indicate extensions.

It will be observed that the lower part of the shell contracted longitudinally, notwithstanding the fact that the tubes were extended by reason of the exterior pressures to which they were subjected.

This behavior calls for bending at the flanges of the heads to compensate for the difference in direction of these movements. The six through braces would relieve the shell of a portion of the longitudinal tension coming from the heads in the upper half of the boiler.

Longitudinal gaged lengths on the upper part of the shell showed diminished contractions over those observed on the lower portion, or displayed strains of extension. On the very top of the boiler the strains were extensions of a pronounced order.

It was found on diagonal gaged lengths, laid off on courses *B* and *D*, upper quarter of the boiler, that greater extensions were displayed on the converging diagonals over those of diverging directions. The converging diagonals, at 270 pounds pressure, extended 0.0047 inch and 0.0042 inch respectively, against 0.0036 inch and 0.0028 inch displayed on the diverging gaged lengths.

The location of the diagonal gaged lengths on course *D* are shown in Fig. 8, similar lengths having been laid off on course *B*. These results are entered in Fig. 20, in addition to the longitudinal strains. The longitudinal strains, all being those of extension on the top of the boiler, were taken for the strains for each pressure, 90, 180 and 270 pounds respectively. The range and variability of these measurements are seen to be very pronounced. The strains were least in amount at the heads, and generally greater rigidity was displayed at the intermediate girth seams than in the solid sheets, under the earlier pressures. At the middle of the length of the longitudinal seams the maximum extensions were developed, witnessed in this examination of the behavior of the shell.

The results thus far presented, with the exception of those on Fig. 17, have included both the elastic strains and the permanent sets of the different measured lengths.

The permanent sets have been subtracted from the extensions and the stresses corresponding to these resiliences computed, and the results show the tangential stresses in pounds per square inch which were found in different parts of the solid sheets of the shell when the boiler was subjected to pressures of 90, 180 and 270 pounds, respectively.

In looking over those results the usual influence of longitudinal seams, such as were used in this boiler, in intensifying the tangential stresses in the adjacent solid sheets may be pointed out. The excessive stress at the side of the single-riveted manhole patch is clearly shown in the results. The high stresses at the sides of the safety valve nozzle under the maximum pressure will also be noted.

While the results are consistent, nevertheless as an engineering structure the distribution of stresses exhibits a range far beyond that which is expected in other classes of constructive work. The type of boiler being one of the simplest, the extension of this method of test to other types would seem desirable. Such tests might assist in establishing satisfactory rules for steam boiler construction and might reasonably be expected to aid in the framing of regulations governing allowable pressures.

Additional tests were carried out, in which the effect of changes in the manner of supporting the boiler was inquired into. It was supported on the four end lugs in one test, and again in another test most of the weight was carried by the middle lugs. In each case there was a modification in the measured strains, although not in a marked degree. At the end of the test the several courses were seen to have been visibly extended in diameter between the girth seams.

The chemical composition of the steel in course *C* was as follows:

Carbon	0.22
Manganese	0.43
Silicon	0.046
Sulphur	0.028
Phosphorus	0.043

It is recalled that this particular brand of steel, at the time of its manufacture, was not infrequently found to possess a decidedly laminated structure. The laminations were not large, nor likely to cause blisters in the boiler, but they were in places quite numerous.

The metal from course *C*, the only sheet yet examined, was found to have a laminated structure. The metal drifts well, a ¾-inch diameter punched hole having been drifted cold to 1¼-inch diameter without rupture.

The services of Mr. P. W. Brunner and J. W. Herrity are acknowledged, whose skill as manipulators is shown by the internal evidence of reliability which these measurements taken by them furnish.

One feature of the investigation for the abatement of smoke in Chicago is the obtaining of information on yard locomotives, freight trains, freight transfer trains, passenger transfer trains and passenger trains operating within the city and in and out of the city. A great deal of information has been collected on the subject. A definite conclusion has been reached in relation to the use of coke as locomotive fuel, and it has been decided to eliminate coke entirely from further consideration. Such subjects as brick arches and stack blowers in locomotives, as well as down-draft furnaces, steam jets and under-feed stokers, have received much attention. Various printed documents have been issued by the committee, and a memorandum of maps has been prepared for the study of the territory or territories covered by the investigation.

Pittsburg Pure Brand of American Uniform Ingot Iron

BY H. M. FELDMANN

Ingot iron owes its discovery to the search for an iron, or alloy of iron, that, in terms of steel, might be termed non-corrosive, and, naturally, in the development of this material all available evidence on the much vexed question of corrosion was studied with thoroughness.

If we imagine a body containing, both by volume and by weight, 100 percent of metallic iron, we have, as regards iron, the maximum resistance to corrosion, because the density is the highest possible, and there is neither local stress nor impurity, whereby electrolysis and consequent wasting by corrosion is set up. Broadly speaking, therefore, the key to non-corrosiveness is purity, and every increment of departure from 100 percent pure iron represents decreased purity and greater susceptibility to corrosion.

We here class as impurities: carbon, silicon, manganese, phosphorus, sulphur, oxygen and dissolved gases, any of which impurities will militate against resistance to corrosion by reason of induced electrolysis or decreased density.

In general, all processes for the refining of pig iron consist in subjecting it to high temperatures and to oxidizing influences, thereby removing its constituent elements, as oxidation products, either in the form of slag or gases. These constituent elements are removed in the order of their affinity for oxygen, and in the case of pig iron the order of removal is approximately as follows:

(1). Manganese, silicon and sulphur.
(2). Carbon and phosphorus.
(3). Carbon and iron.
(4). Iron.

Therefore, the lower the carbon of the molten mass becomes the greater is the danger of oxidizing the iron, and the aim of any refining process is to accomplish the desired oxidation of the impurities, stopping short of oxidation of the iron itself.

Wrought iron is prepared in the puddle furnace by melting down a charge of, say, 500 pounds of pig iron on a hearth of iron ore, and refining it by removing therefrom practically all of its carbon, silicon, manganese, phosphorus and sulphur. The temperatures available in the puddle furnace are sufficient to melt the pig iron, but as the impurity content becomes lower, and the melting point of the mass is correspondingly raised, the puddle furnace temperatures no longer suffice to keep the mass molten and the charge gradually solidifies. The result at the end of the process is a pasty ball. It, therefore, appears that the iron during the period when it is most susceptible to oxidation is in a solid form, so that the oxides formed must be in a sense external to the iron; that is, they must remain suspended in the mass instead of dissolving in it, as would be the case if the iron were melted. Furthermore, at this stage of oxidation, iron in the molten state would have a high solubility with reference to gases, whereas in the pasty condition its solubility with reference to gases is relatively low. The net result of the puddling process is an iron low in carbon, manganese, phosphorus, sulphur, silicon and dissolved gases, while such oxides as may be present are not dissolved in the metal itself, but exist as intergranular patches, which, upon rolling, become elongated into intergranular fibers, causing the so-called fibrous appearance so often erroneously attributed to the iron itself. The product is, therefore, a metal of the very highest excellence with reference to corrosion, being characterized by a high degree of density and also of purity. Furthermore, the amount of metal handled at one time is necessarily small, and from the nature of the process becomes intimately mixed, insuring uniformity in the making, while the final product is never molten and is not cast into ingots, so that no opportunity is given for separation of the impurities on solidification, according to the well-known laws of segregation, which have been so ably worked out by Prof. Howe and others. In other words, wrought iron has earned and maintained its deservedly high position in the esteem of the engineering profession by virtue of its high purity, density and homogeneity, and *in spite of, not because of*, the intergranular slag particles above referred to.

If, therefore, it were possible to obtain an iron as pure, or purer, than the best wrought iron, with reference to carbon, manganese, phosphorus, sulphur and silicon, *in the molten condition*, so that the intergranular slag might float out; if we could maintain it in such molten condition without permitting any oxidation of the iron of the bath to occur; if, moreover, we could in large measure prevent any solution of gases by the bath, and if, finally, we could cast this molten product into ingots in such wise that it would solidify non-selectively; that is, without localizing or segregating the impurities, we should have a product actually superior to the best wrought iron ever made. Such a metal has been the end and aim of all our metallurgical research, and such a metal we believe we have finally obtained in ingot iron.

Ingot iron is prepared by a series of reactions practically identical with those employed in the puddling furnace, the main difference being that, following the usual open-hearth process, the metal is maintained in the molten condition, while at the end of the process, when the total impurities have been reduced to practically nil (care being taken to avoid super-oxidation), the temperature of the bath is raised to a very high degree, so that the slag escapes from the molten mass, instead of remaining therein as in the case with wrought iron. The metal is cast into ingots, and because there are practically no impurities to separate out, no segregation of the impurities occurs, except such as can be wholly eliminated by a reasonable amount of cropping. Not only during the process are proper measures taken to prevent super-oxidation and solution of gases, but at the end of the process, by way of safeguard, suitable processes are employed for removing any oxide of gases that may have eluded our efforts and found their way into the iron.

A very striking instance of the lasting qualities of pure, dense iron is found in a chain forming a part of the suspension of a bridge built at Newburyport, Mass., about the year 1808, and fully described by A. P. Mills, assistant professor of materials, Cornell University, on pages 251 to 282, inclusive, of the April number of the *Cornell Civil Engineers*.

Several links of this chain are now in our possession, showing the following analysis, which for the sake of the lesson taught, we have taken the liberty of correlating with a typical analysis of ingot iron:

LINKS FROM NEWBURYPORT BRIDGE.

Carbon	.05
Manganese	Trace
Phosphorus	.032
Sulphur	.009
Silicon	.019

TYPICAL INGOT IRON.

Carbon	.015
Manganese	.018
Phosphorus	.009
Sulphur	.018
Silicon	Trace

* Paper read before the American Institute of Steam Boiler Inspectors.

Aside from the actual corrosion it has been conclusively demonstrated that the life of a pipe, which might of itself be reasonably long, is frequently, and indeed usually, seriously abbreviated by the occurrence of pits, such pitting being due local impurities or to the presence of patches of steel less dense than the surrounding portions. Practically all soft steel pipes now in commission have shown up very badly in service owing to this fact. One of our strongest claims for ingot iron is its practically absolute uniformity and homogeneity, the chances of pitting being thereby reduced to a minimum.

The above remarks may be applied as well to boiler tubes.

Ingot iron is a new product, which has had no chance to prove itself by long periods of actual service. It necessarily follows that we are compelled to substantiate many of our conclusions by means of laboratory experiments, and among such laboratory experiments we have given a very prominent place to the acid test. We have prepared prints showing, in a striking manner, what ingot iron will really do under such acid tests. We are aware that the acid test has been very adversely criticised, but, nevertheless, after carefully casting about for a convenient test of the widest possible application, we decided upon the acid test in question, and have had absolutely no reason to regret our decision; because while at first we naturally felt that possibly the very favorable results of the acid test overstated our case, all reliable reports of ingot iron in service have not only confirmed the finding of the acid test but have surpassed our very highest expectations.

A great many comprehensive tests have been developed, not only by ourselves, but by users and prospective users of ingot iron, wherein this material was tested out in comparison with steel and other grades of iron in contact with all kinds of acids, and various combinations of acid, of different degrees of strength and at different temperatures. The results of every one of these tests clearly show that the life of ingot iron is from four to ten times that of steel or any other brand of iron manufactured at the present time.

Incidentally, we would call your attention to our blue prints, from which important conclusions can be drawn, merely pointing out that while the samples of ingot iron shown have been subjected to acid of the specified strength for the full period of three hours, as noted in the blue prints, the sample of steel and charcoal iron really had to be removed from the acid at the expiration of one and a half hours' time, as otherwise we could have had practically none of either left to paste upon the prints. The washer print also shows the irregular manner in which steel is attacked by the acid, as opposed to the uniform attack shown by the ingot iron, the phenomenon observed in the steel being akin to the pitting, which is recognized as one of the main objections to pipe manufactured of soft steel. This simply goes to support our great contention, namely, that owing to the great variation in quality among steels and common irons of the same grade from various makers, and due to details of manufacture, ingot iron is the only commercial product of the kind to-day available whose uniformity can invariably be depended upon.

With reference to the deportment of ingot iron under actual service test, we recently had brought to our notice a test made by a coal mining company at Edri, Pa., on boiler tubes of ingot iron, charcoal iron and steel, respectively. They immersed a weighed 10-foot length of 4-inch boiler tube of each of the above materials in the sump water of one of their coal mines for a period of five weeks. What is left of the charcoal iron resembles a piece of rusty and dilapidated stove-pipe more than anything else we can think of. The steel shows a much greater uniformity than is usually found, and the corrosion has taken place quite symmetrically, although much wasting has occurred. The ingot iron tubes, on the other hand, have lost very slightly in weight, the surface has scarcely been touched, and the threads on the end of it are just as fit for the couplings as they were on the day they were cut. The relative deportment of mild steel and charcoal iron boiler tubes under such conditions has been investigated before, and so the endurance of ingot iron in these tests is particularly noteworthy.

Further, steel companies who operate plate mills are perpetually confronted with the problem of a suitable roofing material, because the clouds of salty steam which arise from the plate in the process of rolling attack the steel roofing with the greatest rapidity. A very striking example of the happy manner in which ingot iron solves this problem has just occurred at our mill, the Allegheny Steel Company.

Two and a half years ago they covered the *east* slope of their plate mill roof with ingot iron, and *six months later* renewed the steel roofing on the *west* slope. To-day the steel roofing requires renewal, while the ingot iron on the east slope is absolutely sound and apparently good for twenty years to come, and this in spite of the fact that the east side, which is now ingot iron, formerly required *two* steel roofs to the west side's one, because of the up-river winds which drive the steam and salty vapor from the plate mill toward it. This comparative test is eminently fair, because the ingot iron sheets were of the same gage as the ordinary steel sheets formerly used, were corrugated on the same machine and were painted with the same class of paint.

Again, one of the officers of a copper company informed us some months ago that he had put a roof of ingot iron on one of his buildings where he had always experienced great trouble from the action upon the roofing material of the sulphurous gases created by some of his processes. At the time he talked with us he stated that the ingot-iron roof had already several times outlived any roofing he had previously tried, and he had just recommended the exclusive use of ingot iron for covering all of his buildings.

Fifty or sixty years ago gas holders were built exclusively of iron. It has been necessary recently to wreck a number of these holders, and when cutting out the plates they were found to be in practically as good condition as the day the producers were constructed. Against this, gas holders constructed of ordinary open-hearth steel plates, a matter of ten or twelve years ago, are entirely out of commission on account of having been destroyed by corrosion.

A comparison of the old iron plates with typical ingot iron by discriminating engineers who have made a careful study of gas holders, has prompted them to adopt ingot iron, with the firm belief that it will outlive at least five or six times any ordinary open-hearth steel.

The investigation of ingot iron by engineers of various departments of the government has prompted them to specify this material for use in the construction of some of its equipment which comes in contact with corrosive agents.

We could cite a score or more service tests similar to the above in all of which, as far as the material has been tested in service, the evidence is that the loss, on account of corrosion from any cause, is only from one-fourth to one-tenth of that noted on steel or any other brand of iron placed in comparison with the ingot iron.

In reference to the ductility of ingot iron and its admirable welding qualities no more striking illustration can be pointed out than its excellent deportment under the severest distortion tests to which we have been able to subject ingot iron in the form of boiler tubes.

In short, we believe that ingot iron solves the problem of a homogeneous, uniformly non-corrosive iron, available in commercial quantities and at a price not greatly above that of ordinary mild steel; an iron that equals in longevity and uniformity the best wrought iron ever manufactured and surpasses it in purity. We believe that in all situations it will outlast many times any steel you could possibly apply to the purpose.

Rules for Inspection and Testing of Locomotive Boilers

At a general session of the Inter-State Commerce Commission, held at its office in Washington, D. C., June 2, 1911, at which were present Commissioners Judson C. Clements, Charles A. Prouty, Franklin K. Lane, Edgar E. Clark, James S. Harlan, Charles C. McChord and Balthasar H. Meyer, the following order was issued in the matter of the preparation, approval, and establishment of rules and instructions for the inspection and testing of locomotive boilers and their appurtenances:

Whereas the fifth section of the act of Congress approved Feb. 17, 1911, entitled "An act to promote the safety of employees and travelers upon railroads by compelling common carriers engaged in inter-State commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto," provides, among other things, "that each carrier subject to this act shall file its rules and instructions for the inspection of locomotive boilers with the chief inspector within three months after the approval of this act, and after hearing and approval by the Inter-State Commerce Commission, such rules and instructions, with such modifications as the commission requires, shall become obligatory upon such carrier: *Provided, however,* That if any carrier subject to this act shall fail to file its rules and instructions the chief inspector shall prepare rules and instructions not inconsistent herewith for the inspection of locomotive boilers, to be observed by such carrier; which rules and instructions being approved by the Inter-State Commerce Commission, and a copy thereof being served on the president, general manager, or general superintendent of such carrier, shall be obligatory and a violation thereof punished as hereinafter provided;" and

Whereas at the expiration of the period of three months after the approval of said act many of the common carriers subject to the provisions thereof had failed to file their rules and instructions for the inspection of locomotive boilers with the chief inspector; and

Whereas the chief inspector thereupon proceeded to prepare for submission to the Inter-State Commerce Commission for its approval rules and instructions for the inspection and testing of locomotive boilers and their appurtenances for such carriers so failing to file the same; and

Whereas upon due notice there came on a hearing before the Inter-State Commerce Commission in the matter of the approval and establishment of the rules and instructions prepared by the said chief inspector, on the 29th day of May, 1911; and

Whereas such carriers as had filed their rules and instructions for the inspection and testing of locomotive boilers and their appurtenances with the chief inspector within three months after the passage of said act asked, through their representatives at said hearing, that such said rules and instructions which did not fulfill the requirements of the proposed rules and instructions prepared by the chief inspector be modified to the extent necessary to conform thereto, and that such of said rules and instructions as prescribed a higher standard than that required by the rules and instructions prepared by the chief inspector be regarded as withdrawn from consideration, and joined in a request that such rules and regulations as had been prepared by the chief inspector and approved by the Inter-State Commerce Commission be established with uniformity for them and all other carriers subject to the act; and

Whereas at the hearing aforesaid the rules and instructions prepared by the chief inspector were submitted to the Commission for its approval and all parties appearing at said hearing were fully heard in respect to the matters involved, and said proposed rules and instructions having been fully considered by the commission:

It is ordered, That said rules and instructions for the inspection and testing of locomotive boilers and their appurtenances, as follows, be, and the same are hereby, approved, and from and after the 1st day of July, 1911, shall be observed by each and every common carrier subject to the provisions of the act of Congress aforesaid as the minimum requirements: *Provided,* That nothing herein contained shall be construed as prohibiting any carrier from enforcing additional rules and instructions not inconsistent with the foregoing, tending to a greater degree of precaution against accidents:

RULES AND INSTRUCTIONS FOR THE INSPECTION AND TESTING OF LOCOMOTIVE BOILERS AND THEIR APPURTENANCES

RESPONSIBILITY FOR THE GENERAL CONSTRUCTION AND SAFE WORKING PRESSURE

The railroad company will be held responsible for the general design and construction of the locomotive boilers under its control. The safe working pressure for each locomotive boiler shall be fixed by the chief mechanical officer of the company or by a competent mechanical engineer under his supervision, after full consideration has been given to the general design, workmanship, age, and condition of the boiler, and shall be determined from the minimum thickness of the shell plates, the lowest tensile strength of the plates, the efficiency of the longitudinal joint, the inside diameter of the course, and the lowest factor of safety allowed.

FACTOR OF SAFETY

The lowest factor of safety to be used for all locomotives in service or under construction on or before Jan. 1, 1912, will be fixed after investigation and hearing and after the expiration of the time allowed for filing specification cards.

The lowest factor of safety to be used for all locomotive boilers which are constructed after Jan. 1, 1912, shall be 4.

TENSILE STRENGTH OF MATERIAL

When the tensile strength of steel or wrought-iron shell plates is not known, it shall be taken at 50,000 pounds for steel and 45,000 pounds for wrought iron.

SHEARING STRENGTH OF RIVETS

The maximum shearing strength of rivets per square inch of cross-sectional area shall be taken as follows:

Iron rivets in single shear	38,000 pounds
Iron rivets in double shear	76,000 pounds
Steel rivets in single shear	44,000 pounds
Steel rivets in double shear	88,000 pounds

A higher shearing strength may be used for rivets when it can be shown by test that the rivet material used is of such quality as to justify a higher allowable shearing strength.

RULES FOR INSPECTION

The mechanical officer in charge at each point where boiler work is done will be held responsible for the inspection and repair of all locomotive boilers and their appurtenances under his jursidiction. He must know that all defects disclosed by any inspection are properly repaired before the locomotive is returned to service.

The term inspector as used in these rules and instructions, unless otherwise specified, will be held to mean the railroad company's inspector.

INSPECTION OF INTERIOR OF BOILER

Time of Inspection.—The interior of every boiler shall be thoroughly inspected before the boiler is put into service, and whenever a sufficient number of flues are removed to allow examination.

Flues to Be Removed.—All flues of boilers in service, except as otherwise provided, shall be removed at least once every three years, and a thorough examination shall be made of the entire interior of the boiler. After flues are taken out the inside of the boiler must have the scale removed and be thoroughly cleaned. This period for the removal of flues may be extended upon application if an investigation shows that conditions warrant it.

Method of Inspection.—The entire interior of the boiler must then be examined for cracks, pitting, grooving, or indications of overheating and for damage where mud has collected or heavy scale formed. The edges of plates, all laps, seams and points where cracks and defects are likely to develop or which an exterior examination may have indicated, must be given an especially minute examination. It must be seen that braces and stays are taut, that pins are properly secured in place, and that each is in condition to support its proportion of the load.

Repairs.—Any boiler developing cracks in the barrel shall be taken out of service at once, thoroughly repaired, and reported to be in satisfactory condition before it is returned to service.

Lap-Joint Seams.—Every boiler having lap-joint longitudinal seams without reinforcing plates shall be examined with special care to detect grooving or cracks at the edges of the seams.

Fusible Plugs.—If boilers are equipped with fusible plugs

BOILER FORM No. 1. **MONTHLY LOCOMOTIVE BOILER INSPECTION AND REPAIR REPORT.**

Month of ...., 191   LOCOMOTIVE { Number .... { Initial ....

.... *Company.*

In accordance with the act of Congress approved February 17, 1911, and the rules and instructions issued in pursuance thereof and approved by the Interstate Commerce Commission, I hereby certify that on ...., 191 , at ...., I inspected the boiler of Locomotive No. .... and the appurtenances thereof, operated by the .... Company; that all defects disclosed by said inspection have been repaired, except as noted on the back of this report; that to the best of my knowledge and belief said boiler and appurtenances are in a proper condition for use and safe to operate with a steam pressure of .... pounds per square inch.

1. Safety valves set at .... lbs. .... lbs. .... lbs., on 191
2. Steam gauges tested and left in good condition on ...., 191
3. Was boiler washed and gauge cock and water glass cock spindles removed and cocks cleaned? ....
4. Were both injectors tested and left in good condition? ....
5. Were all steam leaks repaired? ....
6. Condition of flues and fire-box sheets ....
7. Condition of stay bolts and crown stays ....
8. Number of crown and stay bolts renewed ....
9. Condition of arch or water bar tubes, if used ....
10. Date of previous hydrostatic test 191

...., *Inspector.*

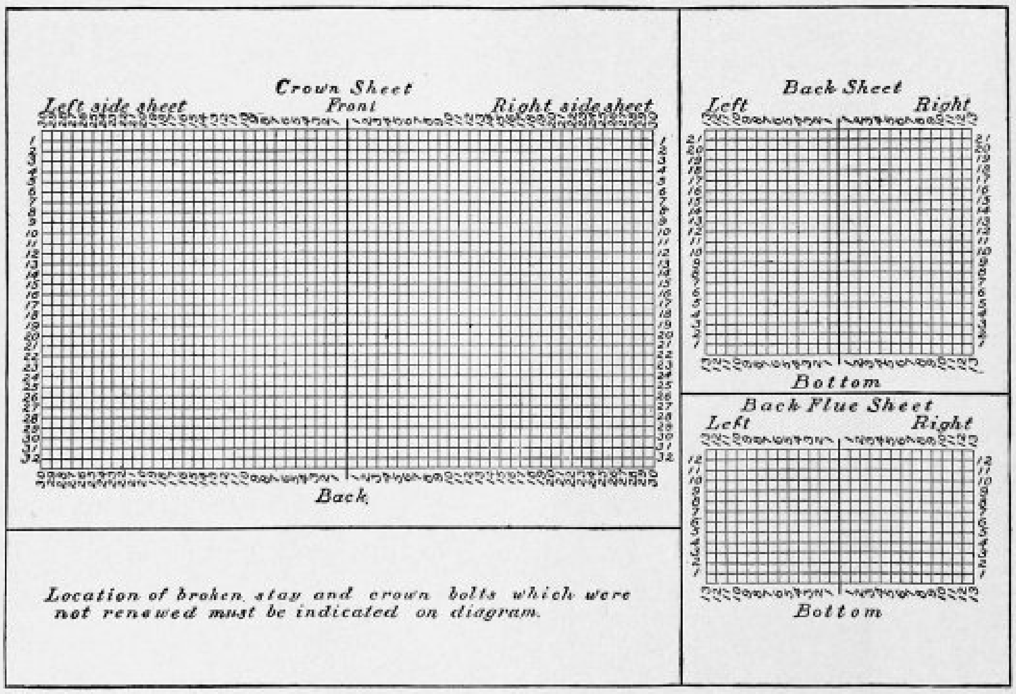
STATE OF .... }
COUNTY OF .... } *ss:*

Subscribed and sworn to before me this .... day of ...., 191 , by ...., known personally to me to be .... of the .... Company at ....

...., *Notary Public.*

I hereby certify that to the best of my knowledge and belief the above report is correct.

(This certificate not to be folded.)   12—449   ...., *Officer in Charge.*



they shall be removed and cleaned of scale at least once every month. Their removal must be noted on the report of inspection.

INSPECTION OF EXTERIOR OF BOILER

Time of Inspection.—The exterior of every boiler shall be thoroughly inspected before the boiler is put into service and whenever the jacket and the lagging are removed.

Lagging to Be Removed.—The jacket and lagging shall be removed at least once every five years, and a thorough inspection made of the entire exterior of the boiler. The jacket and lagging shall also be removed whenever, on account of indications of leaks, the United States inspector or the railroad company's inspector consider it desirable or necessary.

TESTING BOILERS

Time of Testing.—Every boiler, before being put into service and at least once every twelve months thereafter, shall be subjected to hydrostatic pressure 25 percent above the working steam pressure.

Removal of Dome Cap.—The dome cap and throttle standpipe must be removed at the time of making the hydrostatic test and the interior surface and connections of the boiler examined as thoroughly as conditions will permit. In case the boiler can be entered and thoroughly inspected without removing the throttle standpipe the inspector may make the inspection by removing the dome cap only, but the variation from the rule must be noted in the report of inspection.

Witness of Test.—When the test is being made by the railroad company's inspector, an authorized representative of the company, thoroughly familiar with boiler construction, must personally witness the test and thoroughly examine the boiler while under hydrostatic pressure.

Repairs and Steam Test.—When all necessary repairs have been completed, the boiler shall be fired up and the steam pressure raised to not less than the allowed working pressure, and the boiler and appurtenances carefully examined. All cocks, valves, seams, bolts and rivets must be tight under this pressure and all defects disclosed must be repaired.

STAY-BOLT TESTING

Time of Testing Rigid Bolts.—All stay-bolts shall be tested at least once each month. Stay-bolts shall also be tested immediately after every hydrostatic test.

Method of Testing Rigid Bolts.—The inspector must tap each bolt and determine the broken bolts from the sound or the vibration of the sheet. If stay-bolt tests are made when the boiler is filled with water, there must be not less than 50 pounds pressure on the boiler. Should the boiler not be under pressure, the test may be made after draining all water from the boiler, in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

Method of Testing Flexible Stay-Bolts with Caps.—All flexible stay-bolts having caps over the outer ends shall have the caps removed at least once every eighteen months, and also whenever the United States inspector or the railroad company's inspector consider the removal desirable in order to thoroughly inspect the stay-bolts. The fire-box sheets should be examined carefully at least once a month to detect any bulging or indications of broken stay-bolts.

Method of Testing Flexible Stay-Bolts without Caps.—Flexible stay-bolts which do not have caps shall be tested once each month the same as rigid bolts, and in addition shall be tested once each eighteen months by means of a plug wrench and a bar, sufficient pressure being applied to determine if the bolt is broken.

Broken Stay-Bolts.—No boiler shall be allowed to remain in service when there are two adjacent stay-bolts broken or plugged in any part of the fire-box or combustion chamber, nor when three or more are broken or plugged in a circle 4 feet in diameter, nor when five or more are broken or plugged in the entire boiler.

Telltale Holes.—All stay-bolts shorter than 8 inches applied after July 1, 1911, except flexible bolts, shall have telltale holes 3/16 inch in diameter and not less than 1¼ inches deep in the outer end. These holes must be kept open at all times.

All stay-bolts shorter than 8 inches, except flexible bolts and rigid bolts which are behind frames and braces, shall be drilled when the locomotive is in the shop for heavy repairs, and this work must be completed prior to July 1, 1914.

STEAM GAGES

Location of Gages.—Every boiler shall have at least one steam gage which will correctly indicate the working pressure. Care must be taken to locate the gage so that it will be kept reasonably cool and can be conveniently read by the engine men.

Siphon.—Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gage.

Time of Testing.—Steam gages shall be tested at least once every three months, and also when any irregularity is reported.

Method of Testing. Steam gages shall be compared with an accurate test gage or dead-weight tester, and gages found inaccurate shall be corrected before being put into service.

Badge Plates.—A metal badge plate showing the allowed steam pressure shall be attached to the boiler head in the cab. If boiler head is lagged, the lagging and jacket shall be cut away so the plate can be seen.

Boiler Number.—The builder's number of the boiler, if known, shall be stamped on the dome. If the builder's number of the boiler can not be obtained, an assigned number, which shall be used in making out specification card, shall be stamped on dome.

BOILER FORM NO. 2.

QUARTERLY INSPECTION CARD FOR LOCOMOTIVE CAB.

....

(Name of railroad.)

I hereby certify that the boiler and appurtenances of locomotive No. ......, operated by the above railroad company were inspected on ...., 191.., as required by law and the rules of the Interstate Commerce Commission.

Safety valves and steam gauges were tested on ...., 191...

Last hydrostatic test was made ...., 191..

....

....

Inspector...

NOTE.—This card must be renewed within three months from date of above inspection.

SAFETY VALVES

Number and Capacity.—Every boiler shall be equipped with at least two safety valves, the capacity of which shall be sufficient to prevent, under any conditions of service, an accumulation of pressure more than 5 percent above the allowed steam pressure.

Setting of Safety Valves.—Safety valves shall be set by the gage employed upon the boiler, to pop at pressures not exceeding 6 pounds above the allowed steam pressure, the gage in all cases to be tested before the safety valves are set or any changes made in the setting. When setting safety valves the water level in the boiler must not be above the highest gage cock.

Time of Testing.—Safety valves shall be tested under steam at least once every three months, and also when any irregularity is reported.

WATER GLASS AND GAGE COCKS

Number and Location.—Every boiler shall be equipped with at least one water glass and three gage cocks. The lowest gage cock and the lowest reading of the water glass shall be not less than 3 inches above the highest part of the crown sheet. Locomotives which are not now equipped with water glasses shall have them applied on or before July 1, 1912.

Water-Glass Valves.—All water glasses shall be supplied with two valves or shut-off cocks, one at the upper and one at the lower connection to the boiler, and also a drain cock so constructed and located that they can be easily opened and closed by hand.

Time of Cleaning.—The spindles of all gage cocks and water glass cocks shall be removed and cocks thoroughly cleaned of scale and sediment at least once each month.

All water glasses must be blown out and gage cocks tested before each trip, and gage cocks must be maintained in such condition that they can be easily opened and closed by hand without the aid of a wrench or other tool.

Water and Lubricator Glass Shields.—All tubular water glasses and lubricator glasses must be equipped with a safe and suitable shield, which will prevent the glass from flying in case of breakage, and such shield shall be properly maintained.

Water-Glass Lamps.—All water glasses must be supplied with a suitable lamp properly located to enable the engineer to see the water in the glass.

BOILER FORM NO. 3.

ANNUAL LOCOMOTIVE BOILER INSPECTION AND REPAIR REPORT.

.... *Company.* | LOCOMOTIVE { NUMBER .... INITIAL ....

In accordance with the act of Congress approved February 17, 1911, and the rules and instructions issued in pursuance thereof and approved by the Interstate Commerce Commission, I hereby certify that on ...., 191 , at ...., I inspected the boiler of Locomotive No. .... and the appurtenances thereof, operated by the .... Company; that all defects disclosed by said inspection have been repaired, except as noted on the back of this report; that to the best of my knowledge and belief said boiler and appurtenances thereof are in a proper condition for use, and safe to operate with a steam pressure of .... pounds per square inch.

1. Date of previous hydrostatic test ...., 191
2. Date of previous removal of flues ...., 191
3. Date of previous removal of lagging from barrel ...., 191
4. Date of previous removal of caps from flexible stay bolts ...., 191
5. Were all flues removed? ....
6. Number of flues removed ....
7. Was all lagging on fire box removed? ....
8. Was all lagging on barrel removed? ....
9. Were caps removed from all flexible stay bolts? ....
10. Were dome cap and throttle standpipe removed? ....
11. Hydrostatic test pressure of .... pounds was applied.
12. Were both injectors tested and left in good condition? ....
13. Were steam gauges tested and left in good condition? ....
14. Safety valves set to pop at .... pounds .... pounds .... pounds.
15. Was boiler washed; water glass cocks and gauge cocks cleaned? ....
16. Were all steam leaks repaired? ....
17. Number of broken crown stays and stay bolts renewed ....
18. Condition of exterior of barrel ....
19. Condition of interior of barrel ....
20. Condition of fire-box sheets and flues ....
21. Condition of arch tubes ....
22. Condition of water-bar tubes ....
23. Condition of cross stays ....
24. Condition of throat stays ....
25. Condition of sling stays ....
26. Condition of crown bars, braces, and bolts ....
27. Condition of dome braces ....
28. Condition of back head braces ....
29. Condition of front flue sheet braces ....

....................................., *Inspector.*

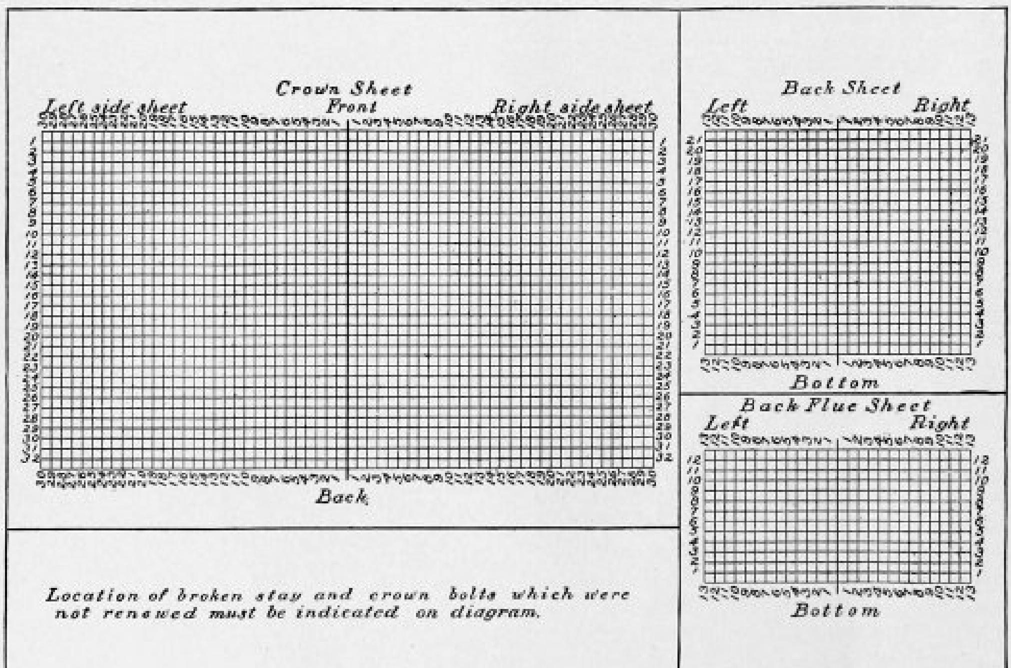
I hereby certify that to the best of my knowledge and belief the above report is correct.

....................................., *Officer in Charge.*

STATE OF .... } ss:
COUNTY OF ....

Subscribed and sworn to before me this .... day of ...., 191

(This report not to be folded.) 12—450 ...., *Notary Public.*



INJECTORS

Injectors must be kept in good condition, free from scale, and must be tested before each trip. Boiler checks, delivery pipes, feed-water pipes, tank hose and tank valves must be kept in good condition, free from leaks and from foreign substances that would obstruct the flow of water.

FLUE PLUGS

Flue plugs must be provided with a hole through the center not less than ¾ inch in diameter. When one or more tubes are plugged at both ends the plugs must be tied together by means of a rod not less than ⅝ inch in diameter. Flue plugs must be removed and flues repaired at the first point where such repairs can properly be made.

WASHING BOILERS

Time of Washing.—All boilers shall be thoroughly washed as often as the water conditions require, but not less frequently than once each month. All boilers shall be considered as having been in continuous service between washouts unless the dates of the days that the boiler was out of service are properly certified on washout reports and the report of inspection.

Plugs to Be Removed.—When boilers are washed, all washout, arch and water bar plugs must be removed.

Water Tubes.—Special attention must be given the arch and water bar tubes to see that they are free from scale and sediment.

Office Record.—An accurate record of all locomotive boiler washouts shall be kept in the office of the railroad company. The following information must be entered on the day that the boiler is washed:

(*a*) Number of locomotive.

(*b*) Date of washout.

(*c*) Signature of boiler washer or inspector.

(*d*) Statement that spindles of gage cocks and water glass cocks were removed and cocks cleaned.

(*e*) Signature of the boiler inspector or the employee who removed the spindles and cleaned the cocks.

STEAM LEAKS

Leaks Under Lagging.—If a serious leak develops under the lagging, an examination must be made and the leak located. If the leak is found to be due to a crack in the shell or to any other defect which may reduce safety, the boiler must be taken out of service at once, thoroughly repaired, and reported to be in satisfactory condition before it is returned to service.

Leaks in Front of Engine Men.—All steam valves, cocks and joints, studs, bolts and seams shall be kept in such repair that they will not emit steam in front of the engine men so as to obscure their vision.

FILING REPORTS

Report of Inspection.—Not less than once each month and within ten days after each inspection a report of inspection, Form No. 1, size 6 by 9 inches, shall be filed with the district inspector of locomotive boilers for each locomotive used by a railroad company, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive.

A copy of the monthly inspection report, Form No. 1, or a quarterly inspection card, Form No. 2, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive before the boiler inspected is put into service.

Not less than once each year, and within ten days after hydrostatic and other required tests have been completed, a report of such tests showing general condition of the boiler and repairs made shall be submitted on Form No. 3,* size 6 by 9 inches, and filed with the district inspector of locomotive boilers, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. The monthly report will not be required for the month in which this report is filed.

*Form No. 3 should be printed on yellow paper.

Specification Card.—A specification card, size 8 by 10½ inches, Form No. 4, containing the results of the calculations

BOILER FORM 4.

SPECIFICATION CARD FOR LOCOMOTIVE NO ......

Owned by..Railroad Company
Operated by..Railroad Company

Builder..............................
Builder's No. of boiler..................
When built..............................
Where built..............................
Type of boiler..............................
Material of boiler-shell sheets..............
Material of rivets..............................
Dome, where located..............................
Grate area in sq. ft..............................
Height of lowest reading of gauge glass above crown sheet..............................
Height of lowest gauge cock above crown sheet..............................
Water-bar tubes, O. diam.............. thickness..............................
Arch tubes, O. diam.............. thickness..............................
Fire tubes, number..............................
Fire tubes, O. diam......length..........
Safety valves:
No. Size. Make. Style.
....
....
....
Fire-box stay bolts, O. diam.............. spaced......x..............
Combustion-chamber stay bolts, O. diam. ....
Combustion-chamber-stay bolts, spaced ....x..............
Crown stays, O. diam., top.............. bottom..............................
Crown stays, spaced........x..............
Crown-bar rivets, O. diam., top.............. bottom..............................
Crown-bar rivets, spaced........x........
Water space at fire-box ring, sides........ back..............front..............
Width of water space at sides of fire box measured at center line of boiler, front..................back..........

Shell sheets:
Front tube......thick.
1st course........thick...... I. diam.
2d course........thick...... I. diam.
3d course........thick...... I. diam.
Mem.: When courses are not cylindrical give inside diameter at each end.
Fire box:
Thickness of sheets—
Tube......Crown......Side........
Door..............................
Combustion chamber..............
Inside throat (if tube sheet is in two pieces)..............................
External fire box:
Thickness of sheets—throat.......... back head..............................
Roof..............sides..............
Dome inside diam..............................
Thickness of sheet........base...... liner..............................
Were you furnished with authentic records of the tests of materials used in boiler?..............................
Records on file in the office of the........ of the....................Company show that the lowest tensile strength of the sheets in the shell of this boiler is:
1st course.........pounds per sq. in.
2d course.........pounds per sq. in.
3d course.........pounds per sq. in.
Is boiler shell circular at all points?.....
If shell is flattened, state location and amount..............................
Are all parts thoroughly stayed?..........
Are dome and other openings sufficiently reinforced?..............................
Is boiler equipped with fusible plugs?....

Make working sketch here or attach drawing of longitudinal and circumferential seams used in shell of boiler, indicating on which courses used, and give calculated efficiency of weakest longitudinal seam.

The ma.. mum stresses at the allowed working pressure were found by calculation to be as follows:

Stay-bolts at root of thread.......... lbs. per sq. in.
Stay-bolts at reduced section .... lbs. per sq. in.
Crown stays or crown bar rivets at root of thread or smallest section, top .... lbs. per sq. in.
Crown stays or crown bar rivets at root of thread or smallest section, bottom .... lbs. per sq. in.

Round and rectangular braces .... lbs. per sq. in.
Gusset braces .... lbs. per sq. in.
Shearing stress on rivets .... lbs. per sq. in.
Tension on net section of plate in longitudinal seam of lowest efficiency, pounds per sq. in. ....

Dimensions and data taken from locomotive were furnished by....................
Data upon which above calculations were made were obtained from drawing No. ...., dated .... furnished by.............. Company.

....
Mechanical Engineer.

STATE OF ....
County of.................... } *ss:*

...................., being duly sworn, says that he is the officer who signed the foregoing specification; that he has satisfied himself of the correctness of the drawings and data used; has verified all of the calculations, and has examined the record of present condition of boiler, dated ...., and sworn to by inspector ...., and believes that the design, construction, and condition of boiler No. .... renders it safe for a working pressure of .... pounds per square inch.

....
(Name of affiant.)

Subscribed and sworn to before me this ..., day of ......, 19...

....
Notary Public.

Approved:

....

made in determining the working pressure and other necessary data shall be filed in the office of the chief inspector of locomotive boilers, for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculation will permit. Where accurate drawings of boilers are available, the data for specification card, Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

ACCIDENT REPORTS

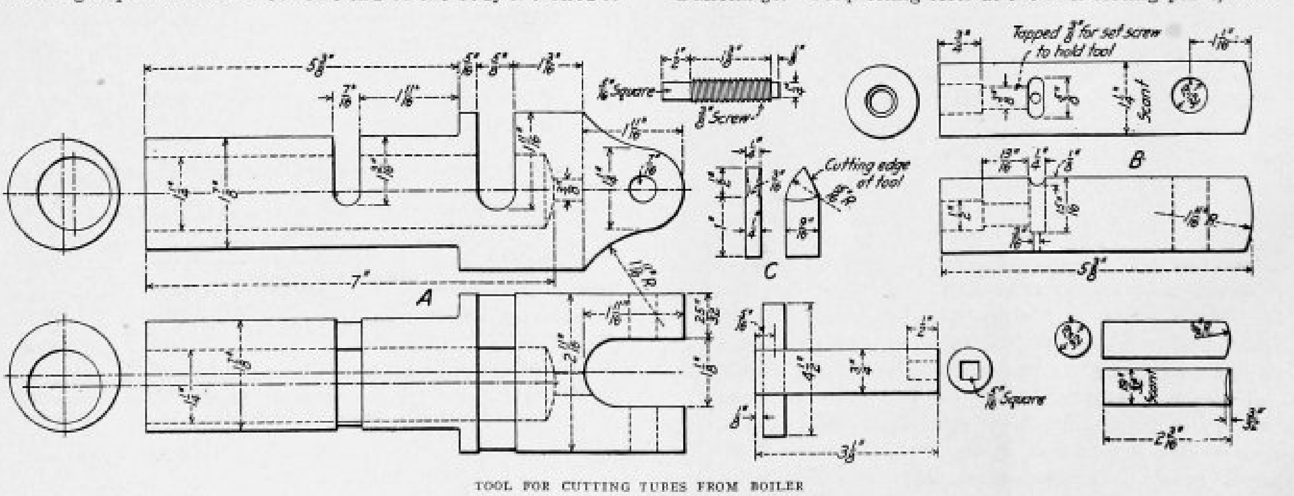
In the case of an accident resulting from failure, from any cause, of a locomotive boiler, or any of its appurtenances, resulting in serious injury or death to one or more persons, the carrier owning or operating such locomotive shall immediately transmit by wire to the chief inspector of locomotive boilers, at his office in Washington, D. C., a report of such accident, stating the nature of the accident, the place at which it occurred, as well as where the locomotive may be inspected, which wire shall be immediately confirmed by mail, giving a full detailed report of such accident, stating, so far as may be known, the causes, and giving a complete list of the killed or injured.

Tube Cutter*

BY H. C. WILSON

A tool for cutting tubes from boilers is shown in Fig. 1. It consists of a machine steel body *A*, a cast steel tool holder *B*, and a high-speed steel tool *C*. One end of the body is turned to fit the tube and a 1¼-inch hole is bored way through it and 5/16-inch off center for the tool holder. There are two slots, 7/16-inch and ⅝-inch wide, cut in the body one-half the way through, one for the tool and the other for the pin which drives the tool holder. The other end of the body is slotted out for a knuckle joint connection. The tool holder is turned to fit the hole in the body; it has a hole for the pin and a slot in which the tool is held by a set screw applied from the end of the holder. The dimensions of the tool are shown on the drawing. It is not hardened and has cut as many as 800 flues with one grinding.

To set the cutter, place the tool holder in the body and adjust the tool so that it extends beyond the body on the thin side, but not on the thick side. Have the tool face the thick side and clamp in position by the set screw. Place the body in the tube up to its shoulder and put in the driving pin so that it rests against the thick side. Turn the body so that the pin will be driven by the thin side. One revolution is sufficient to completely cut off the tube. This tool costs about $3, and the cutters from 4 to 5 cents each.



TOOL FOR CUTTING TUBES FROM BOILER

* From the *Railway Age Gazette*.

New Publications of the Bureau of Mines, Department of the Interior

BULLETINS

Bulletin 6.—Coals available for the manufacture of illuminating gas, by A. H. White and Perry Barker. 1911. 77 pp. 4 pls.

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REPRINTS

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Tests of Large Boilers at the Detroit Edison Company*

BY D. S. JACOBUS

Many engineers have held the opinion that eventually much larger steam boilers will be used than those in service. The size of turbo-electric generating sets has increased by rapid strides, and it might seem that an increase in the size of boilers would naturally follow. There has been a strong feeling, however, that it would be unwise to employ very large boiler units, as a failure of one of the large units would throw out of use a much greater proportion of power than the failure of a smaller unit.

Each of the boilers described in this paper is required, in the all-day practice of the power plant, to carry a load of 6,000 kilowatts and in the evening to carry 7,000 or 8,000 kilowatts. The experience in regular service of eighteen months with the first boiler and of nine months with the second and third boilers has proven this to be good practice. The rated capacity of each boiler is 2,365 horsepower on the basis of 10 square feet of boiler heating surface per horsepower. Fourth and fifth boilers are now being installed, and it is expected to complete the installation of ten boilers of this size within the next two years.

The engineering world is greatly indebted to the Detroit Edison Company and to Alex. Dow, the general manager of that company, member of this society, for pioneer work in installing boilers of two or three times the capacity of the largest boilers heretofore used, and for the opportunity of conducting the most elaborate and painstaking series of tests ever made on a boiler. The preliminary and regular tests required that the boiler room of a large power house be under the control of the observers for nearly three months, and for six weeks over fifty men worked in eight-hour shifts, night and day, exclusively on the tests. All the water and coal was accurately weighed, and much work was done about the plant to avoid the possibility of leakage affecting the results. The magnitude of the undertaking may be appreciated when attention is drawn to the total quantities measured, which were as high as an average per hour of 8 tons of coal, 75 tons of feed water and 1 ton of ashes, the totals amounting to about 5,000 tons of coal weighed and 45,000 tons of water.

The tests were run under the direct supervision of the writer, assisted by men chosen from the engineering staff of the Babcock & Wilcox Company. In addition to the men furnished by the Detroit Edison Company, the Solvay Process Company provided a number of observers. Their experimental engineer, Lewis C. Rogers, co-operated in securing the results and rendered most valuable assistance. Westinghouse, Church, Kerr & Company co-operated in designing apparatus and in making arrangements for the tests and was represented in the tests. The Solvay Process Company made heat determinations and analyses of the coal used in each test, and of the ashes. Duplicate samples were taken, and the work was done a second time in the laboratory of the Babcock & Wilcox Company. The average of the results secured by the two laboratories was used in working up the tests. The tanks for weighing the water had each a capacity of 20,000 pounds. Three such tanks and scales were provided, two being used regularly and the third held for a spare in case any irregularity developed in either of the other two. The coal was weighed by means of four special scales carrying overhead hoppers, each of about 2,500 pounds capacity. The coal was conducted from the regular chutes into the hoppers, which were provided with hinged bottoms held in place by latches.

Two series of tests were made, one on a boiler fitted with Roney stokers, the other on a boiler fitted with Taylor stokers. Front and side views of the former are shown in Figs. 1 and 2. Fig. 3 shows a side view of the boiler fitted with Taylor stokers. Four Roney stokers were used in the furnace, two being at the front and two at the rear of the boiler. There was a low division wall between the stokers, and between the two sets of stokers a bridge wall. The Taylor stokers had thirteen retorts on the front side and thirteen on the rear, or twenty-six in all. The retorts on each side were set in a continuous row, so as to provide an unbroken fire surface from one side of the boiler to the other. There was no bridge wall between the stokers, and when the dumping plates at the rear of each of the Taylor stokers were covered with fuel there was a continuous fuel bed beneath the entire boiler. The width of the furnace from one side to the other of the boiler was about 26½ feet, and the depth of the furnace from the front to the rear of the boiler about 14 feet. The height of the furnace, measured above the dumping grates to the top of the first baffle, was about 29 feet. The large furnace volume, combined with the particular form and height of the furnace, had much to do with obtaining the high efficiencies.

The boilers were built by the Babcock & Wilcox Company. Each boiler contained 23,654 square feet of effective boiler heating surface, and was provided with superheaters for supplying approximately 150 degrees of superheat. The grate surface, measured from the beginning to the rear of the dumping grates, was 446 square feet for the Roney stokers and 405 square feet for the Taylor stokers. This method of measurement is not that usually employed in determining the grate surface of an underfeed stoker, but it was used in order to obtain comparative figures for the two stokers.

The design and installation of the plant and the general arrangement of the boilers and piping were under the charge of Westinghouse, Church, Kerr & Company. This firm designed the arrangement of the furnace brickwork for both the Taylor and Roney stokers; supervised the construction and followed up and corrected the minor defects which developed. Their engineering work in this connection involved the solution, on a large scale, of the problems which were anticipated and which arose, and was an important factor in determining both the makers and the users of boilers to undertake the new departure. Westinghouse, Church, Kerr & Company also co-operated in working out many of the construction details. This work and the general arrangement of the apparatus for the tests was under the charge of Henry O. Pond, to whom the author is indebted for valuable assistance.

In the development of the large units at Detroit, Mr. Dow expected an increase in economy due to minimizing the radiation losses and to the high temperature obtainable in the large furnaces and combustion chamber. He also expected a reduction in the first cost, not on account of a reduced cost per unit of boiler surface, but to a less cost of the settings, floor space, suspension structures, valves and piping. Troubles through brickwork were anticipated, and there were troubles which, in the main, have been overcome.

Another most important feature that had to be considered with so large a boiler unit was the possibility of tube troubles. In dealing with this point Mr. Dow inferred that their experience at the plant with the feed water used in connection with boilers of a similar general type, warranted the conclusion that they should have practically no trouble with the tubes. This has been borne out by the experience with the boilers in actual service.

Mr. Dow credits his friend, Mr. W. H. Patchell, for the first

* From a paper read before the American Society of Mechanical Engineers, New York, December, 1911

idea of the possibilities of large boilers. The boilers and settings at Detroit have no similarity to those installed by Mr. Patchell, but Mr. Dow says that to him is due the first conception of the economical possibilities of the large units and the capacity obtainable through utilizing the whole floor area for the furnace.

A resumé of the results obtained is given in Tables 1 and 2. Table 1 contains the results of tests of the boiler run with Roney stokers, and Table 2 of a boiler run with Taylor stokers. Figs. 4 and 5 show the results of these tests graphically.

It will be seen on examining the tables and figures that the combined efficiency of the boiler and furnace varies from about

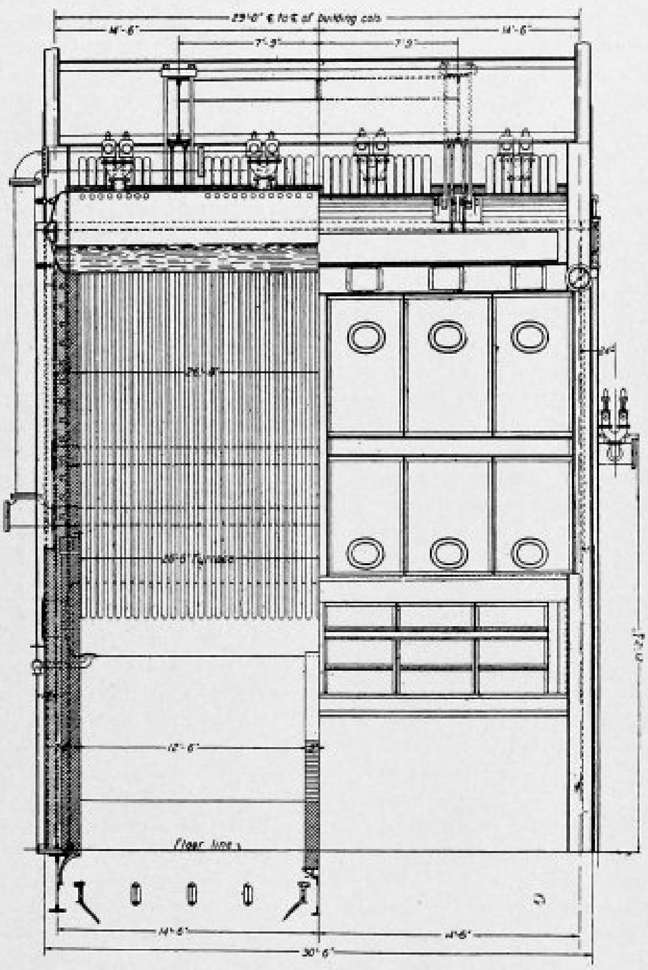


FIG. 1.—FRONT AND HALF SECTION OF BOILER OF 2,365 RATED HORSEPOWER, FITTED WITH RONEY STOKERS

80 percent at slightly below rating to about 76 percent at double rating. In obtaining these efficiencies the steam used for driving the stokers and for producing the forced blast for the Taylor stokers has not been deducted from the total steam generated by the boiler. The amount of steam used by the Roney stokers was about 1½ percent of the total steam generated by the boiler, and for the Taylor stokers about 2½ to 3 percent. The effect that this steam would have on the plant economy depends on the ability to utilize the same for heating the feed water. In a plant where the heat in the steam exhausted from the auxiliaries is returned to the feed water there would be but little loss. In the case of the Taylor stokers all of the exhaust steam from the turbines driving the forced-blast fans may be carried to the feed-water heater, whereas with the Roney stokers only about one-fifth of 1 percent of the 1½ percent used may be so returned, since the greater part of the steam is used in the jets which supply steam beneath the ignition arches of the stokers, and passes away with the chimney products. In a plant in which the auxiliaries are electrically driven, any power to operate the forced-blast apparatus would be a direct loss, and, assuming in the case of the Taylor stoker that the steam consumption corresponding to the current required to drive the electrical auxiliaries is one-half of that found in the tests, the steam required to operate each of the stokers would be about the same. It therefore follows that the effect of the steam for driving the stokers on the station economy cannot be generalized, but that each plant must be considered by itself.

The efficiencies secured are exceptionally high, and the question may be asked whether this is due entirely to the large size of the boiler units. A careful study of the test data shows that the efficiencies were obtained with the most economical furnace conditions, and that the thoroughness with which the fuel was consumed in the furnace had much to do with the

TABLE 1.—TESTS WITH RONEY STOKER. RÉSUMÉ OF PRINCIPAL RESULTS

No. of Test.	Length, Hour.	Percent Rating.	B. t. u. in Coal.	Percent Ash in Dry Coal.	Efficiency.	Percent Steam Used by Stoker Engines and Steam Jets.	Percent Combustible in Ash.	Temp. of Flue Gases Leaving Boiler, Deg. Fahr.
1	25	105.0	14,362	5.98	77.85	....	19.6	576
2	24	80.0	14,225	6.52	79.88	....	17.9	480
3	24	113.8	14,208	7.40	77.45	0.63	24.4	542
4	30	152.4	13,756	6.54	75.78	1.58	30.8	670
5	24	94.0	13,896	6.89	81.15	1.75	31.6	483
6	24	150.7	14,037	6.13	75.28	1.45	26.7	662
16	32	98.6	14,476	9.68	80.98	1.34	34.1	460
17	16.5	193.3	14,493	8.24	76.73	1.39	24.6	636
18	24	195.7	13,689	9.81	75.57	1.32	23.2	694
2-4†	90	119.8	14,098	6.81	76.13	....	25.8	572
5-6†	55	127.3	13,977	6.84	76.23	....	29.4	575

† Including periods between tests.

TABLE 2.—TESTS WITH TAYLOR STOKER. RÉSUMÉ OF PRINCIPAL RESULTS

No. of Test.	Length, Hour.	Percent Rating.	B. t. u. in Coal.	Percent Ash in Dry Coal.	Efficiency.	Percent Steam Used by Stoker Auxiliaries.*	Percent Combustible in Ash.	Temp. of Flue Gases Leaving Boiler, Deg. Fahr.
7	24	151.2	14,000	7.03	77.07	2.61	31.5	575
8	24	107.9	13,965	6.34	80.28	2.44	27.1	493
9	50	162.8	13,998	6.75	77.85	2.87	31.3	574
10	48	92.9	14,188	9.90	77.90	2.63	27.2	487
11	26.5	211.3	14,061	9.55	75.84	3.41	36.1	651
12	48	121.3	14,010	8.09	79.24	2.57	27.6	535
14	24	185.2	14,272	8.71	76.42	2.95	28.8	647
15†	24	123.1	14,213	8.34	74.90	2.77	30.1	561
7-9‡	109	140.0	13,983	7.22	77.66	2.68	29.9	545
10-11‡	80.5	132.8	14,095	9.58	75.66	3.04	31.1	542

* Engines driving stokers and steam turbine driving fan.
† In test No. 15 the fires were banked for 7½ hours and the averages included this period.
‡ Including periods between tests.

attainment of the high figures. On examining Figs. 1, 2 and 3, showing the general arrangement of the boilers and settings, it will be seen that the roof of the furnace has an A-shape, and that the coal is fired at the front and rear of the boiler setting. With this arrangement the character of the combustion may be maintained constant from one side of the boiler to the other, and the loss so often experienced through a stream or lane of excess air or unconsumed combustible gases passing through the boiler and escaping to the stacks will be avoided. Those conversant with the subject know that in ordinary boiler furnaces there is a great variation in analyses taken from different points in the path of the flue gases leaving the furnace, whereas with the present furnace arrangement this action is reduced to a minimum, as any irregularity from the front to the rear of the grates disappears before the gases pass from the upper part of the combustion chamber, and as the composition of the gases for uniform firing conditions will be uniform from one side of the boiler to the other, or from right to left in Fig. 1, it follows that the composition of the entire volume of the gases leaving the furnace will be substantially uniform.

A straight reference line is drawn in Figs. 4 and 5 in order that the results obtained by the two stokers may be readily compared, this line being the same on both diagrams. It will be noted that the test results fall on both sides of the line, and that the efficiency obtainable with each stoker is about the same. Naturally a curve should be used instead of a straight line to show the variation in the efficiency, but the accidental variation in the test results is such that it would be impossible to trace an exact curve.

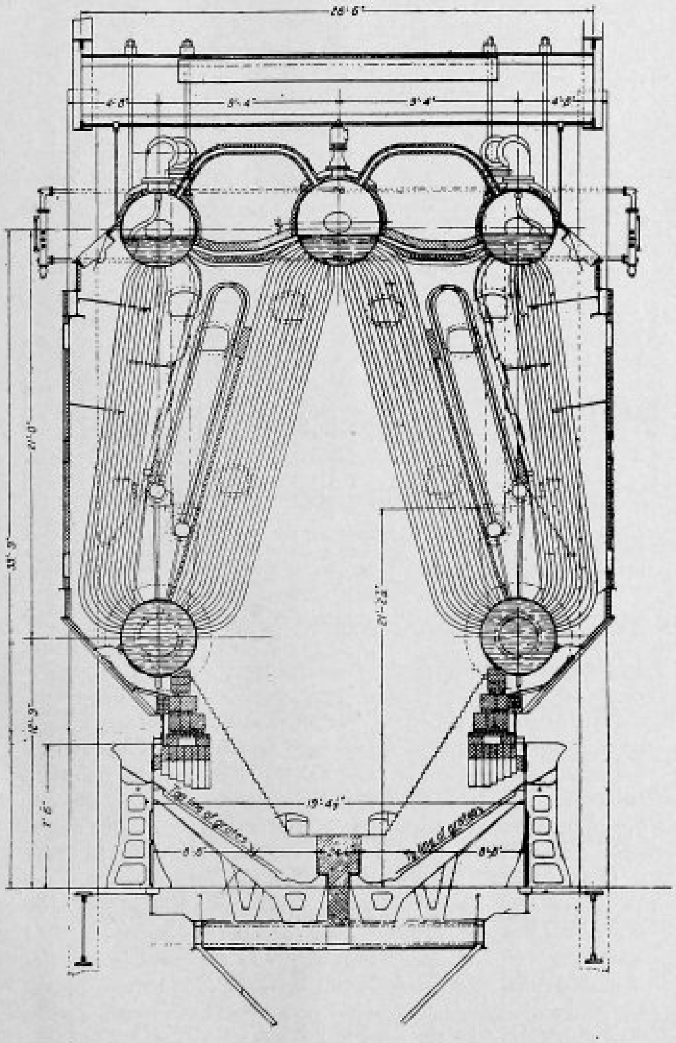


FIG. 2.—LONGITUDINAL SECTION OF BOILER FITTED WITH RONEY STOKER

On examining Fig. 4, it will be seen that the efficiencies, where several tests are worked out together, including the periods between the tests, are only about 1½ percent lower than would be indicated by averaging the results for the separate tests by passing a straight line between the points. The same follows for the tests which are worked up together for the Taylor stoker. This shows that including the periods between the tests, during which the dust was blown from the exterior of the tubes and the firing was not watched as carefully as it was during the tests, did not greatly lower the efficiency. It was proposed at first to run a test of a week or more on each of the stokers, but this plan was abandoned, since there was trouble through leakage in the feed pump which made it necessary to shut down, and on reconsidering the matter it was deemed advisable to give up running as long a test as this, since it developed that a week would be too long a period to run without blowing down the boilers. It was found that the efficiency, including a banking period of seven and one-half hours, is about 75 percent.

It will be seen (Figs. 4 and 5) that the average amount of steam used for driving the Roney stoker was about 1½ percent at all loads, and that it varied from about 2½ percent at rating to about 3 percent double rating for the Taylor stoker. Saturated steam from another boiler was used for driving the auxiliaries. The saturated steam was reduced to its equivalent weight of superheated steam in determining the percentages above given.

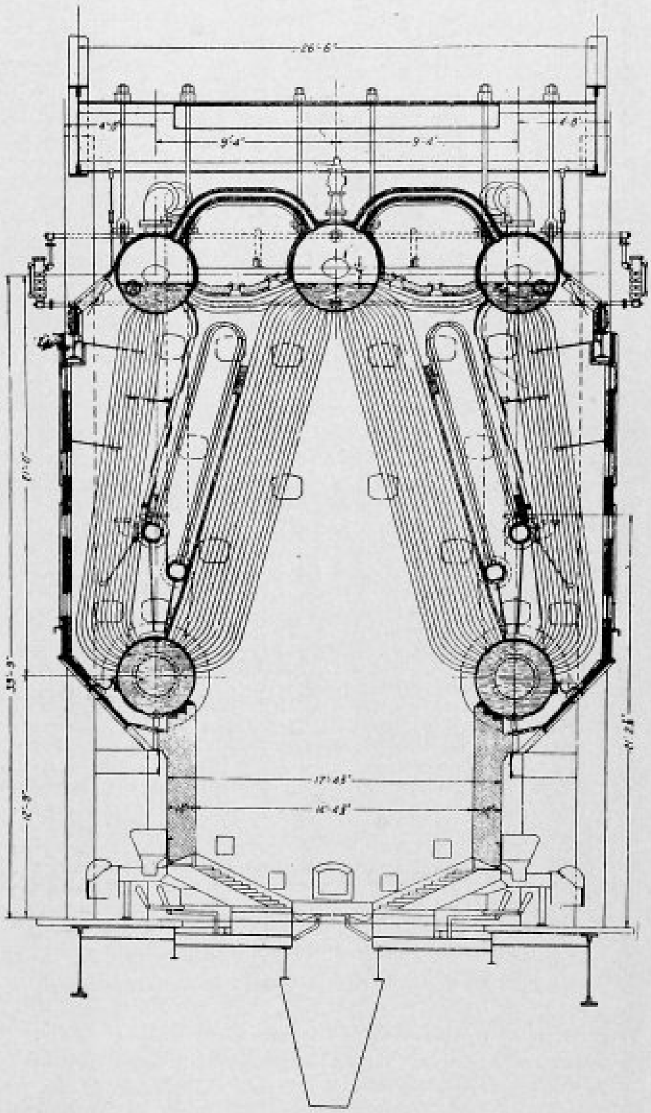


FIG. 3.—LONGITUDINAL SECTION OF BOILER FITTED WITH TAYLOR STOKER

The minimum length of a regular test was twenty-four hours. The efficiency fo. a test of sixteen and one-half hours is plotted in one diagram. In this particular test a special coal was used which ran out and thus brought the test to a close. Some of the tests were forty-eight hours' duration and over. A continuous record was kept, and the efficiency was determined for periods embracing several of the tests including the intervals between them. Intervals were selected from some of the tests and were worked up to obtain comparative results. It was noted that there is a substantial agreement between the results secured in the regular tests and the results for the selected intervals. It must not be inferred from this that sufficient accuracy would be secured by shortening the length of the tests. The tests reported in this paper were made after a painstaking series of preliminary tests with both of the stokers, and the operators were well trained

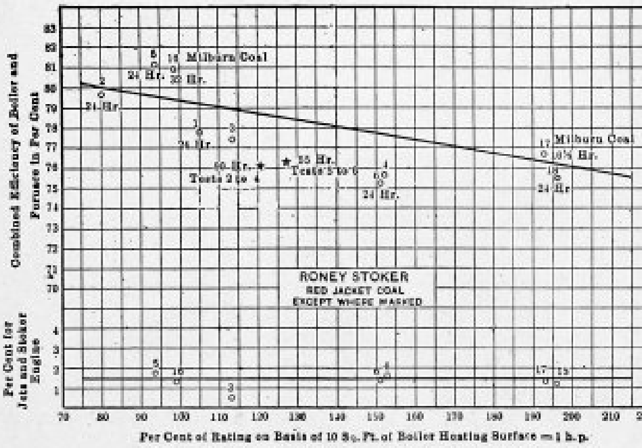


FIG. 4.—RESULTS OF TESTS OF BOILER WITH RONEY STOKER

in maintaining uniform conditions. Twenty-four hours is none too long an interval for obtaining accurate results with an underfeed stoker of the class tested, as one can readily appreciate when the fact is called to his attention that the

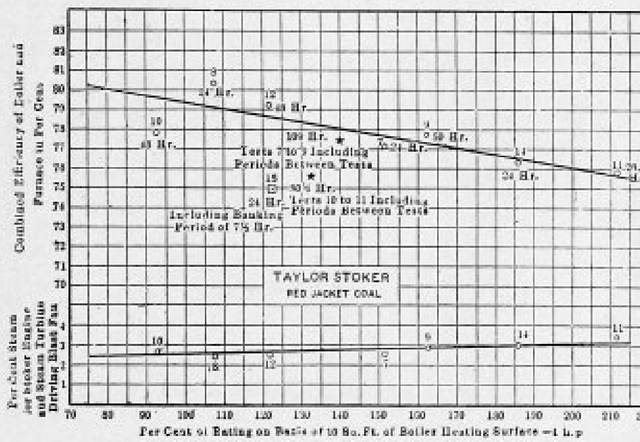


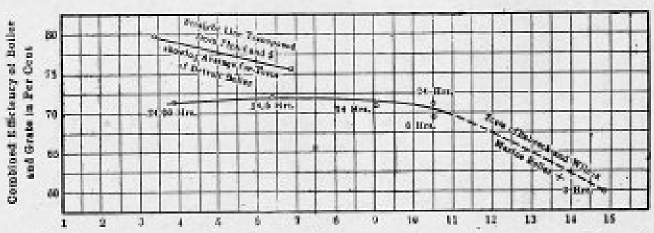
FIG. 5.—RESULTS OF TESTS OF BOILER WITH TAYLOR STOKER

generation of steam will continue after no more coal is fed to the furnace with but little difference in the appearance of the fire. There is no method whereby the fire can be measured except by sizing it up by the eye, as one must form an estimate of the amount of clinker present. One of the operators at the plant was earnest in his opinion that the fires, as balanced up by the author for the Taylor stoker, contained from 2½ to 5 tons more coal at the end of a test than at the beginning, a contention that was shown beyond doubt to be in error by the heat balances. This goes to show how far the estimates of the amount of coal may affect the results, and that, consequently, there is great danger of obtaining erroneous figures in short tests. That an error in estimating the fire may cause a considerable error in a short test is exemplified in one test, where, on account of a leakage at the feed pump, it was necessary to shut down after running eleven and one-half hours. The author was not present to make the final coal balance, and it will be noted that the efficiency is several percent higher than it should be on the basis of the more accurate tests, and, further, that the efficiency secured would not have the proper margin for radiation, etc., in a heat balance. Where the fire may be kept in a comparatively uniform condition, as in the Roney stoker, it might seem that the tests could be shortened, but even in such cases the author is in favor of making twenty-four-hour tests.

Great care was taken to prevent the possibility of leakage affecting the tests. All fittings where there might be leakage were either blanked off or two valves were provided with an open drip between them. The boilers were tested with hydraulic pressure both before and after the tests. Special leakage tests were also made in which the hot boilers were completely filled with water and the full pressure maintained on the boilers and feed mains, and in each case there was no leakage indicated in tests of several hours' duration.

From the average analyses of the flue gases it was found that the furnace efficiency was exceptionally high for both of the stokers.

Two sets of heat balances were made, one applying to the gases after they left the boiler dampers, and the other to the gases at the top of the second pass directly beneath the boiler dampers. The analyses of the gases after leaving the boiler dampers were made with an Orsat apparatus, the samples of gas being obtained from the middle points of the flues. The temperature of the gases directly beneath the boiler dampers



Equivalent evaporation from and at 212 degrees per square foot of heating surface per hour. + Curve dotted for evaporations of over 11 pounds where there are not enough points to determine the exact form.

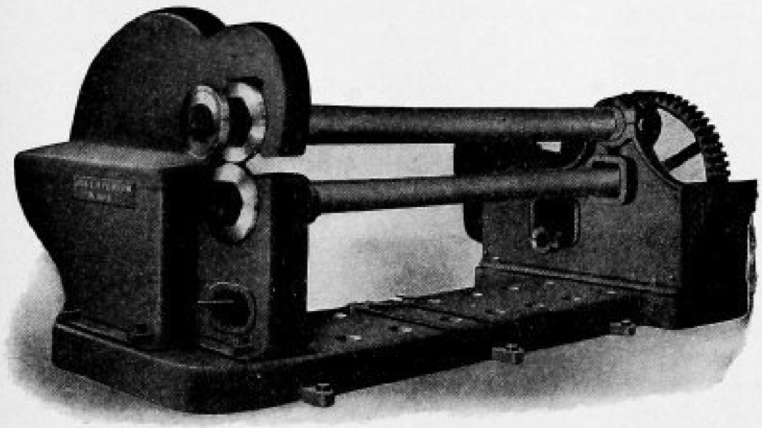
FIG. 6.—COMPARISON OF RESULTS WITH THOSE OF A B. & W. MARINE BOILER

at the top of the second pass was determined by means of electrical couples, two sets being used at each side of the boiler. The analyses of the flue gases at this point were made by a Hempel apparatus, an average sample being obtained by drawing the gas from six points at the front and six points at the rear of the boiler. The gas was drawn through the collecting piping with an aspirator, and a sample of the mixed gases was drawn into a collecting bottle for analysis. In order to make sure that the same weight of gas entered each of the six sampling tubes, a throttling cock was adjusted to make the suction on each tube a given amount, as indicated by a water gage. The Hempel apparatus was also used in the way just described for analyzing the gases at the bottom of the second pass. The apparatus for obtaining the average samples was constructed by the Solvay Process Company.

The results of the heat balances show that the average radiation and unaccounted-for losses are only about 2½ to 3 percent. There is naturally a variation one way or the other due to accidental errors, but the results are as uniform as could be expected in work of the sort.

Preliminary tests were first made on the boiler with the Taylor stoker. The apparatus was then shifted and preliminary tests were made on the boiler with the Roney stoker. A careful study of the operating conditions for the best economy was made in the preliminary tests. The results of the regular tests only are given in this paper.

Readings of temperatures, pressures, etc., were taken every half hour. The water was balanced each hour. The coal weighed per hour and supplied to the hoppers was balanced each hour and recorded, but no attempt was made to obtain



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The machine is fitted with a hold-down wheel which assists in guiding and keeping the plates level on the blades. The tool can be furnished for either belt or motor drive.

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MACHINERY

CHICAGO

New York Office: Hudson Terminal Building a correct coal balance except at the beginning and ending of the tests, as this necessitated running the coal quite low in the hoppers of the stokers. As soon as the data were taken a copy was made on a large sheet in the boiler room, so that those conducting the tests could, at a glance, note whether the conditions were uniform. Marks and Davis steam tables were used in working up the results.

In order to compare the results with others where high efficiencies have been secured, Fig. 7 is presented. In this figure the straight line shown in Figs. 4 and 5 is transferred and marked average for tests of Detroit boiler. The plotted results for individual tests shown in Fig. 7 are for tests made by a board of United States naval officers on a hand-fired Babcock & Wilcox marine boiler, and reported in the *Journal* of the American Society of Naval Engineers, November, 1910. By combining the results secured with the two boilers it will be seen that the efficiency varies from about 80 percent at an evaporation of 3 pounds per square foot of heating surface per hour from and at 212 degrees F. to 76 percent at 7 pounds, 72 percent at 10 pounds and 60 percent at 14.7 pounds. It therefore follows that if the performance of the two boilers could be combined a boiler could be run from about 80 percent of the ordinary rating to over four times this rating, and for most classes of central power-plant service it would be possible to run all of the boilers in the plant all of the time, thus eliminating the loss occasioned through having to carry a number of boilers under banked fires. The writer is now working on the development of a boiler of this sort.

Layout of an Elbow

In answer to the query in the August issue of THE BOILER MAKER regarding the layout of an elbow I submit the following: I have used the same angle given by Mr. Jones, but have not drawn it to scale, as only the method is requested. Draw the plan and elevation with the intersecting pipe *b*. Next draw Fig. 3 at right angles to the intersecting pipe *b*, Fig. 2; draw the center line of the intersecting pipe, Fig. 3, at 45 degrees to the center line of *a*, Fig. 3; draw the center line of *c* at 42 degrees to the center of pipe *b*. Project the center *d'*, Fig. 3, to the plan parallel with *a*, Fig. 3, and at 42 degrees to the center line of pipe *b*, Fig. 3, project the point *d'* to Fig. 2; project the point *d*, Fig. 2, to the elevation. Draw the elbow *c*, Fig. 1, to the desired shape and size. Care must be taken not to diminish the cross-sectional area where *c* intersects *b*.

To find the miter line where *c* intersects *b* proceed as follows: Through the points 4' and 10', Fig. 1, draw a line perpendicular to *h t*, Fig. 5. Make *h t* equal to the height of the center of elbow *c*, Fig. 1. From *h*, Fig. 5, measure off *h t* equal to *D E*, Fig. 2. Draw *j t*. Perpendicular to *j t* draw 1-7. With *j* as a center draw the semi-circle; divide it into six equal spaces and project the points 1, 2, 3, etc., on 1-7 and parallel to *f g* to corresponding lines, Fig. 1. Draw a smooth curve through the points 1', 2', 3', etc., which is the miter line of *c* and *b*. To find the miter line where *b* intersects *a*, draw the profiles, Figs. 1 and 2, as shown. Project the points of intersection in the plan, Fig. 2, to the elevation. Draw a smooth curve through corresponding points 1", 2", 3", etc., which is the line of intersection of *b* and *a*. Next divide half of *c* and *b*, Fig. 2, in six equal spaces; draw the alternates in plan and elevation as shown. From the view *d* and *e*, Fig. 2, and *c* in the elevation, the pattern, half of which is shown in Fig. 8, can be developed. Fig. 6 shows the triangles to find the true length of 4' 3, 3' 3, etc., also *R* 4' and 10' *S*, which form half of the flat sides *R*, 4, 4' and *S*, 10, 10'. Where the center line of *c*, Fig. 3, intersects *e' e* locates the center of top of *c* in Fig. 2.

To develop the opening, Fig. 4, draw *k l* and *m n* perpendicular to *C D*. On *k l* step off 1‴ 2‴, 2‴ 3‴, etc., equal to 1‴ 2‴, 2‴ 3‴, etc., Fig. 2. Perpendicular to *k l* and through 1‴, 2‴, etc., draw 1‴ 1‴, 2‴ 2‴, etc. Project the points 1", 2", 3", etc., Fig. 1, parallel with the base to Fig. 4. Draw a smooth curve through corresponding points of intersection which forms the opening in *a* to receive the pipe *b*. Note that measurements 1‴ 2‴, etc., Fig. 2, were taken as cords of arcs. Where great accuracy is required the line from 1" to 7‴, Fig. 4, must equal the arc of contact 1‴ to 7‴, Fig. 2. The pipe *b*, Fig. 1, can be developed by the parallel method as shown in Fig. 7, and does not need further explanation.

SUBSCRIBER.

The Boiler Blow-Off in Country Life

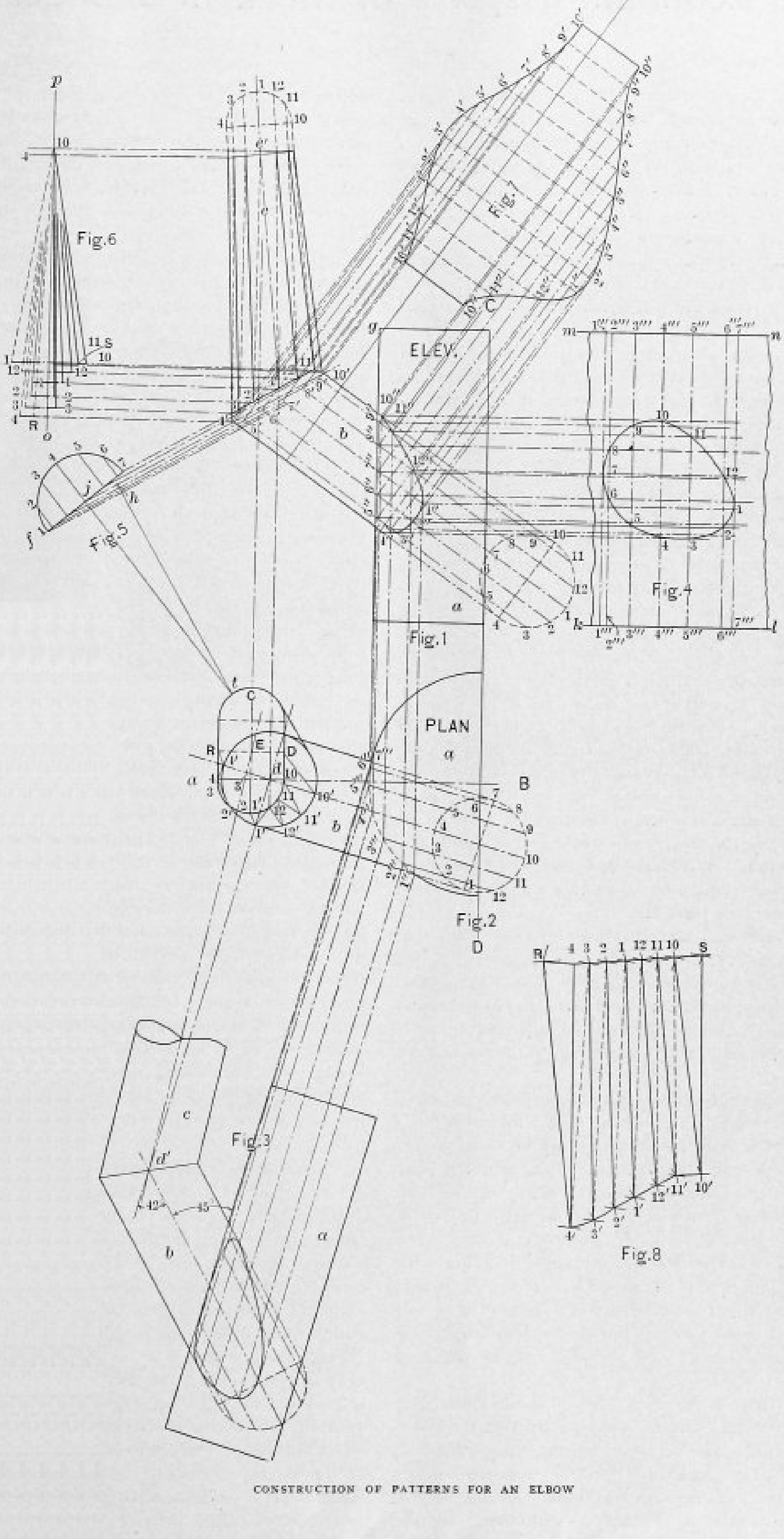
The apple crop was a good one and the peak of the cider-making curve at its highest point. Thus it was that empty whiskey barrels were in great demand, and Farmer Merryweather had gone to the city to gather his quota of containers. For some reason or other one of the barrels was fouled, and the idea occurred to him as he drove by the suburban electric station to clean the barrel with steam. Along the side of the road a 2-inch nipple projected some 8 or 10 inches from the boiler-room wall and about 3 feet from the ground. Many a time had he seen the steam blowing from this pipe, and noted how Wiley, the fireman, had operated the controlling valve by reaching through a hand-hole in the wall. So with Wiley's permission he rolled the blacklisted barrel from the wagon and industriously worked the bunghole over the nipple. He gave no heed, however, to Wiley's caution to remove the plugs from the head openings. Lying on his stomach over the barrel, he reached the valve and let on the steam. The first blow emptied several gallons of hot water into the barrel, and then the boiler pressure began to accumulate. A slight sliding of the barrel aroused him to the necessity of digging the toes of his heavy shoes into the ashes so as to hold the barrel to the wall. The "cleaning" was all over in a minute. That barrel with its human rider flew over the road. Honors were even as to which of the two—the man or the barrel—stayed on top the longer. There were no casualties, however, but it was the most exciting incident ever witnessed by the station force, "'fore nor since." "By ginger!" he exclaimed, "that was a powerful little pipe."

F. WEBSTER.

A Question for Readers to Answer in the Next Issue

One of our subscribers asks that readers who have had practical experience in laying out circular courses of plates and angle-bars tell what is the proper way of doing such work. Should the thickness of the iron be deducted from the outside diameter and added to the inside diameter, or should three and one-quarter times the thickness of iron be added to the circumference for a stack by running a wheel or tape around the course? For a taper course, should three and one-quarter times the thickness of the iron be deducted for the circumference of the small end and added for the large end? Also for an angle-iron ring, should you take off a thickness for the outside and add the thickness for the inside?

According to *The Railway Age Gazette* the number of locomotives ordered in 1911 has been not only smaller than in 1910 but has been small as contrasted with the amount ordered on the average during the past decade. Moreover, the number of locomotives actually built during the year is smaller than the average for the past ten or twelve years. Returns from locomotive builders show that 3,530 were built during the year, of which 143 were for domestic service and 387 for export. Two hundred and twenty-five were compound and 133 were eléctric locomotives, a large part of which have been used for industrial switching service and similar uses. The number of locomotives built in 1910 was 4,755, or 1,225 more than were built in 1911.



CONSTRUCTION OF PATTERNS FOR AN ELBOW

Some Economic Aspects of Stock in a Boiler Shop

BY JOHN ROSS

How much stock should be carried? By "stock" is meant every kind of material—rough, finished, assembled, as the case may be—that is on hand ready to be incorporated in a finished boiler, but has not been bought or made up to fill any specific production order. Under stock should be included, of course, the store-room supplies. If the foundry makes up a lot of 50 fire-doors to be used on future orders those doors are stock, and when complete boilers are built up and stored to fill future sales, they are stock. Supplies of plates, tubes, rivets, staybolt iron, bolts, etc., all form part of the "stock" on hand.

The stock of a boiler shop represents a large amount of tied-up capital. It is an asset which cannot be realized on until it is used to fill production orders—then it gets into circulation again via the price paid for the boiler. It is evident, then, that the shorter time this money lies dormant in the form of stock, the more liquid capital will be at the call of the business. On the other hand, a certain amount of stock must be carried, or costly delays will ensue. It is folly to cut down the stock supply to a point where sudden orders are likely to catch the shop bare of some essential raw material. Where, then, is the safe and economical point half-way between the Scylla of dormant capital and the Charybdis of running out of stock? Which brings us back to our original point—how much stock should be carried?

The first step towards settling the question in any shop should be a careful investigation of the stock record. Is everything that really is stock listed and carried as stock? A very good way to keep the record complete and up-to-date is by carrying every item on a separate card in charge of the stock clerk. All additions and subtractions are shown plainly and the balance on hand is always visible at a glance. A study of these cards at the end of any stated period—a month, perhaps, or six months—will make plain at what *rate* each item has been moving; how long 50 of this will last, or how many of that are used in a month.

Naturally, the rates of different kinds of stock vary tremendously. The card record will show how much. Often some item will not require restocking once in six months, while others may be in sufficient demand to require renewal once a week. Obviously, in the former case the shop is overstocked—in the latter, probably a larger supply should be kept on hand.

With this information at hand—with the *time* element introduced into such a sluggish subject as stock—the most economical point at which to carry each item can be easily ascertained. In this work, the shop superintendent and the purchasing agent must co-operate. Freight rates on car-load lots or less, fluctuation of prices, terms and deliveries, will, of course, all enter into the final classification of each item. These things must be taken into consideration, together with the known *rate* of movement of the stock. It is evident that a bargain lot of 20 tons of material is not a bargain if it will take 2 or 3 years to work through the shop. The interest on the money thus side-tracked will usually exceed the first saving.

By giving due attention to these points a maximum and minimum may be worked out for every stock item. These figures, placed on the cards, serve as an automatic check on the stock as well as a guide to the stock clerk in requisitioning for material. The minimum represents the number of units below which the stock of that material must not be allowed to fall. When this point is reached, the stock-clerk requisitions for a sufficient number of additional units to carry the total up to the maximum—above which the stock must not go. By this simple device, the stock-clerk's judgment is not required to pass on the important matter of "how much stock should be carried." Furthermore, changing conditions will constantly require changes in the limit figures of some stock item. Once in six months or once a year is often enough to check up the cards and note the rates of movement. Maxima and minima can be altered in individual cases to adjust matters to changing conditions at this checking-up time. Also, whenever new stock is bought or made, the cost per unit can be entered in red ink opposite the record of this addition to the stock, and thus an easy reference provided for extending the material costs on orders. For example, a requisition for 50 pounds of ¾-inch by 2½-inch rivets used on some order is sent over to the cost clerk by the store keeper after the latter has delivered the rivets to the shop. The clerk, by referring to the stock card for ¾-inch by 2½-inch rivets, finds that the price paid for those rivets is marked at 1.6 cents per pound. This rate is at once entered on the material requisition and the total of $1.6 \times 50 = \$0.80$ entered on the cost sheet of that order. At the same time the stock card has 50 pounds deducted from the former balance, and the order number and date on which this amount was given out entered opposite. After the transaction, the balance on the card tells as exactly how much is on hand at the moment as the annual inventory does at the end of the twelfth month.

Thus the important matter of stock on hand is automatically regulated, once the rates have been established, and these rates should be determined by careful investigation and the maxima and minima based on the best experience and judgment available. Stock should *move*. Eddies and dead corners always mean an investment that is making no return. Sometimes investigations of the type outlined indicate that some article now carried as stock could be more economically bought or made on orders only. Again, it is often found that articles formerly made on order only should be manufactured in quantities and carried in stock. Whether such results follow, or the study merely proves that the previous practice was correct, a guess is supplanted by accurate knowledge and the work of regulating the amounts of stock and ordering judiciously is reduced to a mere matter of routine clerical work. The purchasing agent then *knows* that he is not in danger of over-stocking, and the shop man is sure that he will not run out of material when it is needed.

News and Trade Papers in Foreign Countries for Advertising Purposes

Advertising in some form is recognized as an essential factor in every effective trade-getting campaign in this country, and this is to a considerable extent true in foreign markets. Most American manufacturers, although familiar with the style and cost of advertising at home, do not have such information regarding foreign countries. In order to furnish those engaged in or desirous of entering the foreign field a general idea of the cost of newspaper advertising abroad and the papers it might be advisable to use, the Bureau of Manufactures of the Department of Commerce and Labor is publishing in *Daily Consular and Trade Reports* a series of reports by American consular officers on foreign news and trade papers. The reports embrace such points as location and class of paper, district covered, circulation, subscription price and advertising rates.

An Exceptional Repair Job on a Swing Type Bridge

One of the most interesting bridge repair jobs on record, both from a mechanical as well as a financial standpoint, was recently performed on one of the Chicago bridges of the Chicago, Milwaukee & St. Paul Railroad. The bridge in question is situated on the north branch of the Chicago River, between Division street and North avenue, and was built in 1902. On account of the small width of the river and the necessity of keeping an open channel, a "through-truss-swing type" of bridge was used. It is 230 feet in length, has unequal arms, and is pivoted on the north bank. The long arm extends across the river and is counterbalanced for overhang.

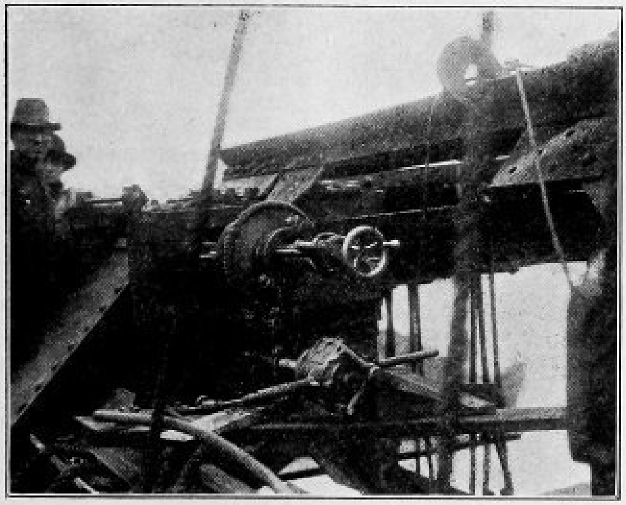


FIG. 1.—BORING BAR IN POSITION

Due to vibration and other intermediate forces, the pins and bearings became so worn that it was deemed advisable to replace them. Previous to this time, all such jobs had been performed by driving piling and erecting false work, under which conditions the members were removed to the shop and rebored. Even under the most favorable circumstances such a rush job would have hindered navigation for several days, notwithstanding the enormous expense coupled with the work. Also, on account of river traffic, some trouble was experienced in receiving Government permission to shut off navigation, so it was finally decided to try a new scheme of boring out the holes and replacing the worn pins with larger ones, without removing any of the members.

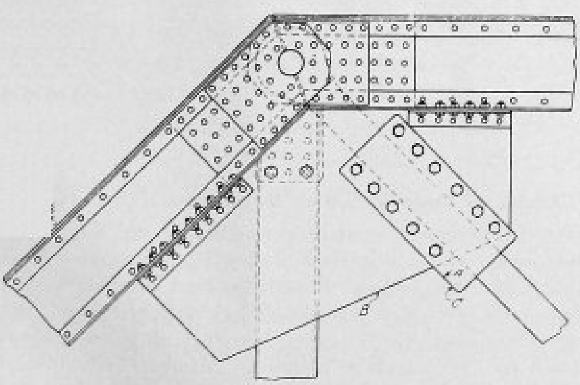


FIG. 2.—ELEVATION

Preparatory to removing each pin, it was necessary to securely clamp the members at the joint, as shown in Figs. 2 and 4. This served to secure them during the boring operation. Steel plates *A*, four in number, were used to hold the eye-bars. These were placed on each side of the eye-bars, with a block of wood, *C*, fitting tightly between the inner two, while the outer two reinforced the plates *B*, which were directly in contact with the eye-bars. The whole was bolted together by 1-inch bolts, thus developing enough friction between the plates to take care of the dead-load stress in the eye-bars. The two plates *B*, one on each side, were fastened to the lower flange of the top chord and to each end post by angles and bolts, and this supported the hanger by bolts, as shown. In this manner, when the pins were driven out, all members were rigidly clamped in position.

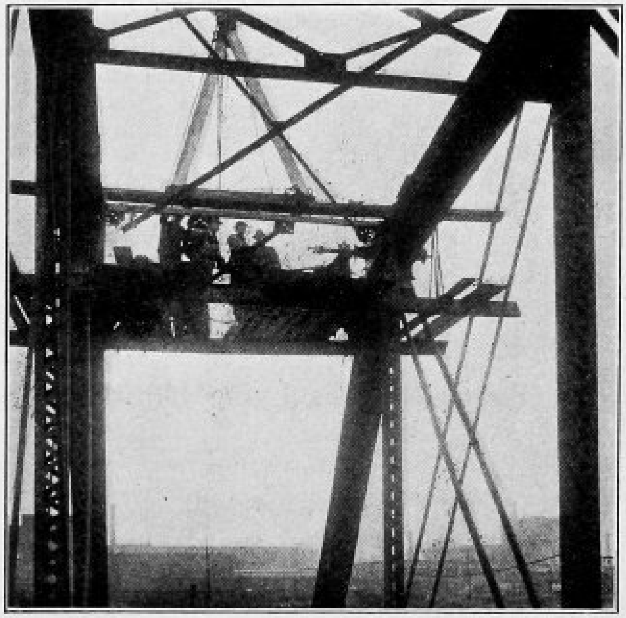


FIG. 3.—GENERAL VIEW OF THE WORK

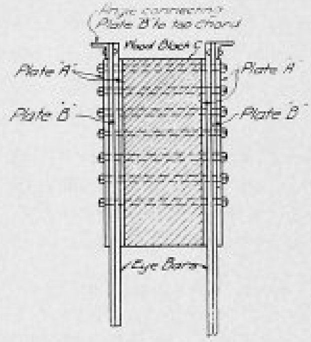


FIG. 4.—SECTION

Upon removal of the pins they were found to be considerably worn and their bearings somewhat enlarged. The holes were rebored from the original 5-inch diameter to 5¼-inch diameter by using a Ryerson portable boring bar. This bar is made by Joseph T. Ryerson & Son of Chicago, and although designed primarily for boring locomotive cylinders in the shop, nevertheless gave perfect satisfaction even under such adverse circumstances. Fig. 3 shows the boring bar in position and the manner of bracing and centering it on the actual job. Fig. 4 is a photograph taken from below, looking up at the work. The power plant consisted of a section car containing a gasoline engine and air compressor. The boring bar was directly driven by a small air drill, which operated the shaft and furnished the required power.

Work on this job was started at 6.00 A. M. on the morning of Nov. 6, and by 8.15 P. M. of the same day the four pins had been removed, holes rebored, new pins inserted, and traffic was passing over the bridge. This is the first time that the use of such a method of reboring bridge work has ever been brought to our notice. The time taken for the actual work was remarkably short, and the whole experiment proved a decided success.

Gallons Per Foot or Inch of Depth in Cylindrical Tanks Lying Horizontal

APPROXIMATE METHOD ACCURATE FOR ORDINARY PURPOSES

To find length of chord *a*. $\sqrt{r^2 - c^2} = b$, $2 \times b = a$, or, as in Fig. 2, $r = 5$ feet, $c = r - i$, or 4 feet; then $\sqrt{r^2 - c^2} = 3$ and $2 \times 3 = 6$, or *a* in Fig. 2. All chords in a like manner. *C* in the next examples would be *r* — the distance from the edge of the circle. To find the area of the top or first division use this formula:

$$\frac{Lr - A\,(r - i)}{2}, \text{ or as in Figs. 1 and 2} = 4.08.$$

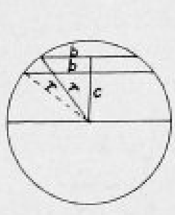


FIG. 1

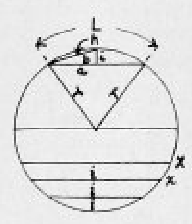


FIG. 2

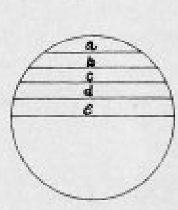


FIG. 3

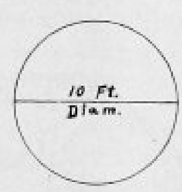


FIG. 4

To find the area of the next division and also the remaining divisions treat each as a trapezoid. To do this, find the length of each chord, as *a-b-c-d-e*, etc., Fig. 3. Add the first and second chords, multiply the sum by the space between chords, as *i*, and divide the product by 2, or $\frac{(a + b) \times i}{2} = 7$.

For the next area or division take the chord *b* and chord *c*, and work $\frac{(b + c) \times i}{2} = 8.59$. The rest are worked likewise.

After all the divisions have been solved find the area of the entire circle and also find the aggregate areas of the divisions. Subtract the latter from the area of the circle, and divide by the number of divisions in the circle and add the quotient to each division. This is done as there is a slight error in each division owing to the curve at *x x*, Fig. 2. To find the cubical contents of each division, multiply the area by the length and by 7.48; there being 7.48 gallons to a cubic foot.

EXACT METHOD

Find the area of the top segment or division as explained by formulæ $\frac{Lr - a\,(r - i)}{2}$ in approximate method. Then find the area of the second segment, *i. e.*, the space between the line *b*, Fig. 3, and the circle. Subtract from that area the area of the first segment; the remainder will be the area of the second division or the space between *a* and *b*, Fig. 3. Then find the area of the third segment, or the space between the line *c* and the circle. Subtract the area of the first and second segment, which leaves the area between *b* and *c*. The remaining areas or divisions are worked likewise.

SOLUTION OF LETTERS IN FIGS. 1 AND 2

$r =$ the radius or one-half of the diameter. In this example $r = 5$ feet.

$i =$ the divisions. In this example $i = 1$ foot.

$a =$ length of each chord, or $2 \times \sqrt{r^2 - c^2}$

$c = r -$ sum of *i*'s used, or the distance from center of circle to chord.

$b =$ one-half of *a*. In Fig. 2 $a = 2 \times \sqrt{5^2 - 4^2}$, or 6 feet for top chord.

$h = \sqrt{B^2 + i^2}$. In Fig. 2 $h = \sqrt{3^2 + 1^2}$, or 3.1622 feet.

$L = \frac{8\,h - a}{3}$. In Fig. 2 $L = \frac{8 \times 3.1622 - 6}{3}$, or 6.4325 feet.

$L\,r - a\,(r - i) \div 2$, as in formulæ for area of first segment, $= \frac{6.43 \times 5 - 6 \times (5 - 1)}{2}$, or 4.08 square feet.

To insure accuracy carry all decimals four places.

J. R. F.

Change of Date of Boiler Manufacturers' Convention

At the executive committee meeting of the Supply Men's Association of the American Boiler Manufacturers' Association, held at the Chicago Pneumatic Tool Company's office in New York, Jan. 2, it was decided to have the New Orleans convention commence Tuesday, March 12, in place of Monday, March 11, as originally planned. Members are, therefore, notified that the twenty-fourth annual convention of the American Boiler Manufacturers' Association will be held at New Orleans from March 12 to the 15th, inclusive, with a banquet on the evening of the 14th.

The usual remedy for stopping a leak from the tell-tale hole in a combustion chamber stay is to drive a taper pin into the hole, cut it off flush and rivet it over to stop the leak until the boiler can be shut down and the stay renewed.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

No appreciable decrease in the annual number of boiler accidents was evident in the United States during the year 1911. Every boiler maker should make it a part of his work in 1912 to promote the establishment of uniform laws for boiler construction and inspection in every State of the Union. The initiative steps in this matter taken by Massachusetts and Ohio could be followed to great advantage by all other States. The good of the community and the welfare of its people demand immediate and concerted action in this direction. We hope the boiler-making craft will not be laggard in this respect.

One of the most notable achievements in the boiler making field during the past year was the completion and the exhaustive testing of two boilers, each of which has a rated capacity, on the basis of 10 square feet of boiler heating surface per horsepower, of 2,365 horsepower; or, in other words, boilers which are two or three times larger than any boiler which has heretofore been installed. In every-day practice each of these boilers carries a load of 6,000 kilowatts, and in the evening from 7,000 to 8,000 kilowatts. Some further idea of the magnitude of the undertaking in building and testing these boilers can be appreciated from the illustrations and data given in this issue and from the fact that the tests required a staff of over fifty men to work for six weeks in eight-hour shifts, night and day, the work involving, among other things, the weighing of 5,000 tons of coal and 45,000 tons of water. The success of these boilers after a year's service should convince many who have been skeptical about the advisability of using such large boiler units that the possibilities of experiencing disastrous losses by the failure of a single unit in the installation are very remote. The combined efficiency of the boiler and furnace varied from about 80 percent at slightly below rating to about 76 percent double rating, and the efficiency was about the same for the two types of mechanical stokers used. These efficiencies were exceptionally high, and were due in large measure to the most economical furnace conditions and the thoroughness with which the fuel was consumed in the furnace, factors which are without question of most importance in boiler service.

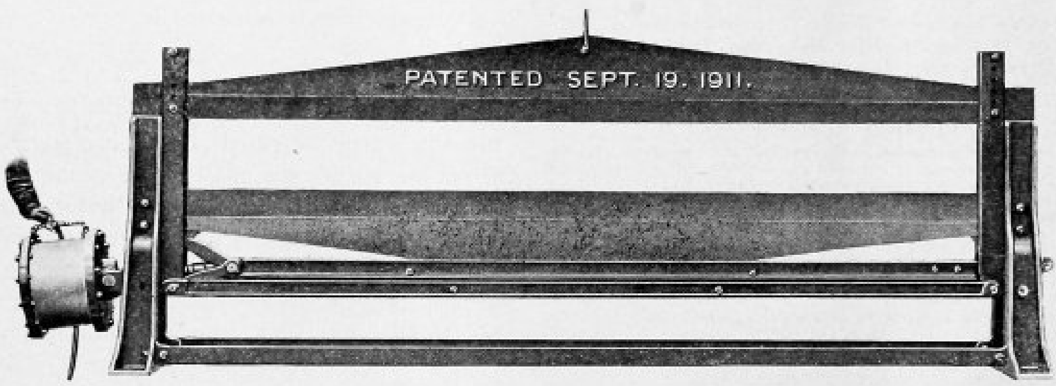
In the matter of research and investigation, where the results are for the good of the community and the safety of the people, the United States is wisely carrying on work which is of the greatest value to the boiler-making industry, and, of course, consequently to the people at large. Lately the Bureau of Standards, Washington, D. C., under the direction of Dr. S. W. Stratton and under the direct supervision of Mr. James E. Howard, of the Bureau, has been making hydrostatic tests on two boilers built twenty-eight years ago of steel. They must, therefore, be among the very first boilers made of this material. The tests were made with a view of seeing the effect of hydraulic pressures on the shell. Gaged lengths were established on different parts of the boilers by means of holes 10 inches apart and about .05 inch in diameter reamed to a conical shape. The deformations of the boilers at different pressures were determined by a 10-inch micrometer strain gage with conical points to fit the reamed holes laid out on the boilers. The utmost care was taken to do the delicate measuring without the possibility of personal error or of there being any misleading data recorded. The results of these tests, which are given in detail in this issue, furnish information never before available. The work is of importance, not merely because it is a splendid example of scientific investigation, but by carrying out this research the Bureau of Standards is doing something which will allow us to eliminate in our equations an unknown or guessed-at quantity; and it seems to us that in so doing public money is being used to its very greatest advantage, as it is being turned from a small local power into a great, widespread knowledge, the value of which cannot be even moderately estimated.

New Improved Engineering Specialties for Boiler-Making

New Flanging Clamp

The illustration on this page clearly represents a new design of single-cylinder toggle joint flanging clamp invented and patented by J. H. Optenberg, president of the Optenberg Iron Works, of Sheboygan, Wisconsin. Some of the readers will perhaps remember that the patentee is a member of the Master Steam Boiler Makers Association, and was in attendance at the convention at Omaha, Nebraska, where he demonstrated a model of the above clamp. Believing that this design would be of great interest to every boiler maker who did not have an opportunity to become familiar with its construction, we will give the following details of its construction and merits.

The main object the inventor had in view when designing this clamp was to overcome the complication of a two-cylinder clamp, doing away with one cylinder, together with the pipe connections leading from one to the other, also the objectionable feature in maintaining the two beams parallel with one another when clamping narrow faced work, also to reduce the consumption of air by two-thirds and still obtaining a greater clamping power than that on a two-cylinder clamp; and it is evident at a glance at the illustration that this has been accomplished in the design of the new clamp.



No matter whether the work is inserted at the center or at either end, the two beams, it is claimed, will always remain parallel with one another. Not only that, but also doing away with a jarring of the beams while bending the flange due to the cushioning of the air, as the toggles will form a firm brace and become tighter as soon as the turning of the flange has begun. It will also be observed that provisions have been made to adjust the length of the reach in order to obtain a uniform clamping power at each end of the clamp. The face of the lower beam is wider than the upper—one side of same is planed square cornered and the other side round to 1½ inch radius for the purpose of bending either a square or standard round flange.

The cylinder is 14 inches diameter by 8 inches stroke, with a regular standard steam snap ring piston, doing away with the objectionable feature in the use of leather becoming saturated with the oil. Besides this the power applied can be either air, steam or water, as the case my be, and hence everlasting. By the piston moving 8 inches outward the upper beam will rise 12½ inches from the lower beam; in other words, leaving a clear opening of 12½ inches. Also the upper beam can be bolted in three higher positions varying 2½ inches each, making the total clearance between beams 20 inches. In lowering the upper beam from this point it will come down within 7½ inches from the lower beam. The advantage in the toggle movement applied to a flanging clamp is this: The only time the power is required above that to raise the upper beam is when the work is to be clamped. In giving the schedule of the results obtained in the two movements between the piston and the upper beam one can readily understand the enormous clamping power obtained when the toggle is in proper position, viz.:

We assume that the clamp is closed. In beginning operation you will find that when the piston moves outward 1 inch the upper section has lifted only 15/32 inch.

The second inch it will rise					11/16	inch.
"	third	"	" "	"	⅞	inch.
"	fourth	"	" "	"	1⅛	inches.
"	fifth	"	" "	"	1½	inches.
"	sixth	"	" "	"	1⅞	inches.
"	seventh	"	" "	"	2½	inches.
"	eighth	"	" "	"	3½	inches.

From this the reader can see that at the beginning of the stroke the piston moves a little over two to one of that on the beam, and vice versa at the end of the stroke. At the first inch or two is where nearly all the clamping is done, especially on heavy work. In case where an odd-shaped form block is used the upper beam is bolted in a higher position between the side guides wherever required according to the thickness of the form block and work to be inserted, leaving the toggle in nearly a straight position when clamping the work; or, in other words, the piston is doing the work in either the first or second inch.

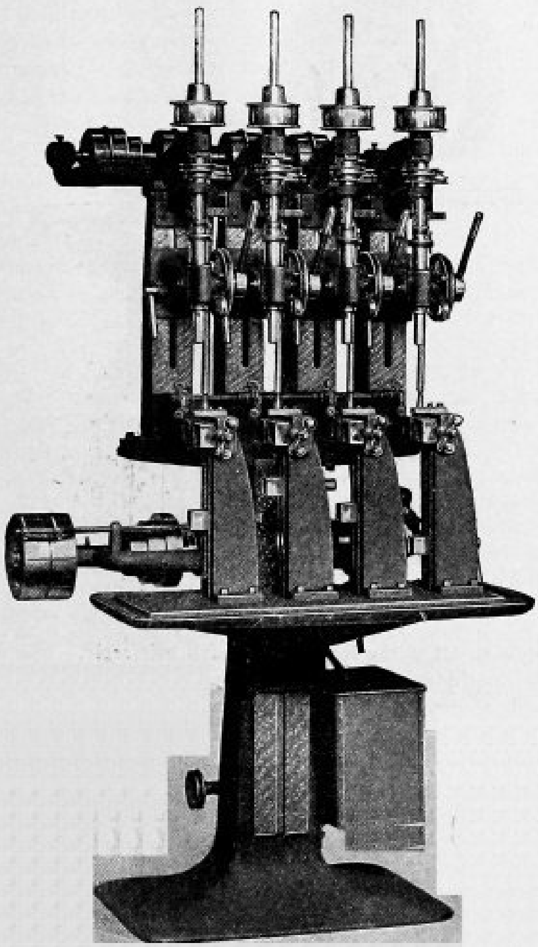
It is claimed the clamp will hold the heaviest plate that can possibly be formed by hand, besides clamping the thinnest plate on the market. The operator can also insert all kinds of odd work due to the wide opening, as in many cases in screw punching, chipping or calking light work, this clamp will apply to great advantage. The clamp is made in five sizes, viz.: 8 feet, 10 feet, 12 feet, 14 feet and 16 feet between housings, leaving 1 inch clearance. The same size cylinder is applied to all sizes.

It will also be noticed that provision has been made to handle the clamp by derrick to locate same on floor wherever desired to do the work, as the machine is portable in every respect. Slot holes are also inserted at the foot of the end standard for anchor bolts if desired to be placed on a concrete foundation.

Jos. T. Ryerson & Son and Scully Steel & Iron Company, of Chicago, Ill., are agents for the above machine. The inventor also is the owner of a quick acting hand-clamp which has been on the market ever since 1903, for which Jos. T. Ryerson & Son and Scully Steel & Iron Company are also agents.

A 4-Spindle Staybolt Drill

In view of the recent recommendation of the Inter-State Commerce Commission in regard to the use of tell-tale holes in boiler stay-bolts, the machine illustrated, which is made by the Foote-Burt Company, Cleveland, Ohio, is of particular interest at this time. Although not a new machine in the strict sense of the word, as there are over a hundred in operation in various railroad and boiler shops at present, this stay-bolt drill has been redesigned to take care of increased strain inseparable from the use of high-speed steel, and is a thoroughly modern and up-to-date tool. The machine has a



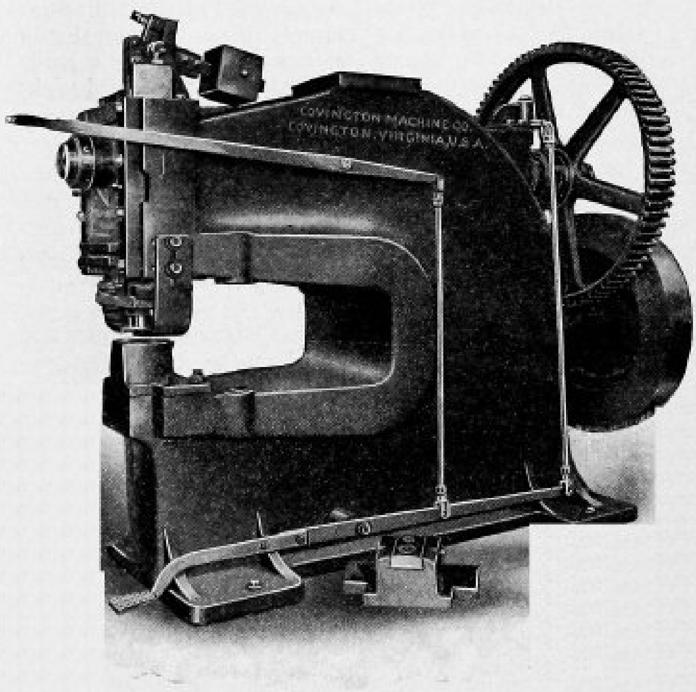
capacity of four 5/16-inch drills, and will take in stay-bolts from ¾ inch to 1¼ inches in diameter and from 3 inches to 15 inches long. Each spindle is provided with three independent speeds, and has two changes of power feed. Power feed is equipped with automatic knock-off, which can be set for any depth within the capacity of the machine. Both feed and speed can be readily changed on any spindle without changing the other spindles. Specially designed chucks, with simple, quick-acting gripping mechanism, center the stay-bolts beneath each spindle and hold them rigidly in position. A hardened bushing is provided for the drill to run in, insuring its starting central with the piece held in the chuck. An oil pump is provided with suitable return tank so that liberal quantities of lubricant can be used. On account of the extremely rigid design of this machine and its ease of operation, it is claimed a boy can readily keep all four spindles running to their maximum capacity, reducing piece costs to the minimum. The stay-bolt chucks are readily removable, leaving the machine available for a variety of sensitive drilling when necessary. These features, it is expected, in connection with the reasonable first cost and extremely low cost of upkeep, make it a tool of exceptional interest to railroad and boiler shop men at this time.

A Boiler Maker's Utility Punch

The accompanying illustration shows a boiler maker's utility punch, recently placed on the market by the Covington Machine Company, Covington, Va. In designing this line of machinery, the following points were given careful consideration:

To make the frame stiff as well as strong, a heavy, cored box section of semi-steel was designed, which resists deflection, and especially the twisting caused by shearing bars. The gap in the frame was made large at the back, so that, when necessary, flanged heads may be pushed in to the full depth of the throat.

The shaft, which requires strength and toughness, was designed with liberal dimensions to avoid excessive bearing pressures and tensile stresses, and is turned from a steel forg-



ing made by reliable manufacturers who guarantee a tensile strength of not less than 70,000 pounds per square inch.

A reliable clutch was provided, which works easily and stops automatically without the use of springs. The clutch is so designed that the punch may be stopped at the top or at any point of the down stroke. The stop mechanism is adjusted for any position by loosening or retightening one, or at the most two, screws. The clutch is usually thrown in by a foot treadle operated by the ball of the foot without lifting the heel from the ground. When punching rivet holes in flanged heads the foot treadle is readily detached, and the clutch operated by a hand lever.

Another point is a safety capstan. The usual form of capstan keyed fast to the plunger shaft is dangerous, for, should a workman forget, leave the bar in the capstan, and start the machine by accident, or through carelessness, damage is apt to result to either the man or machine. This danger is avoided by using a ratchet key in the capstan, which allows it to revolve around the shaft in one direction.

The gears, which must combine strength and quiet running, are made of the latest, stub-tooth design, of semi-steel, cast from cut iron patterns, or, in the case of the larger sizes, machine molded.

The bearings are all bushed, both for the main and the counter shafts. Aside from generous bearing surfaces each machine is given a two-days' run, and then inspected before shipment. This insures, it is claimed, that the machine is ready for continuous work as soon as it is installed.

Belt drive from any direction is provided for. This is arranged by casting a heavy tubular bracket at the rear of the machine, carrying two large bearings. The fly-wheel and the tight pulley are combined in one casting. The fly-wheel is brought back over the outer bearing toward the frame, so that the pull of the belt on the tight pulley comes close to the outer bearing. To remove the countershaft it is only necessary to loosen one set screw.

The machine, as shown, with the tools in position, is arranged to punch tube holes in sheets. To punch the rivet holes in flanged heads, these tools are removed, a punch holder inserted in the front of the plunger, and the hold-down block, shown on the floor, bolted to the base. Other readily detachable fixtures are provided which will shear plates, bars or angles. The larger sizes are furnished with a crane pad on the top of the frame. The machine is easily equipped for motor drive, as the motor may be bolted to the side of the frame, where it is out of the way, above the dirt and dust of the floor, and yet is readily accessible.

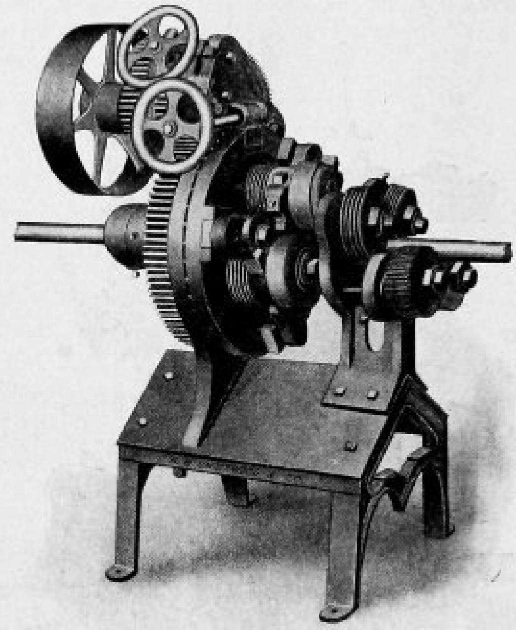
Rotary Flue Cleaner

This machine is designed for removing the hard adhering crust of lime from boiler flues, which is very difficult to remove in a cleaning roller or tumbler, and expensive, also, because of the waste of steam and time. It is claimed that very little power is required to run the machine. It is operated by a laborer, who enters the flues in the machine (one at a time), they being revolved and fed through like a screw, and dropping off on the opposite end without assistance. It is claimed to clean from 8 to 10 feet per minute, removing all scale, and without injury to the flue.

It is so constructed that no countershaft is needed. It is provided with a double clutch gear, which enables it to be reversed in case of special need, and sets the pulley free, to avoid a countershaft. To set the machine it is only necessary to place it in line with the pulley on the shaft from which power is taken.

Three revolving shafts, provided with circular blunt-edged steel cutters, are set obliquely in adjustable boxes, the central line of the flue passing between them; these boxes are connected with a movable ring, governed by a worm screw, which is operated by the lower hand-wheel, and each of them is provided with a small adjustable circular assisting cutter with cross teeth, which cuts the lime lengthways; after being cut crossways by the circular cutting plates on revolving shafts the scale is consequently reduced to square particles in a rough manner; the same process is repeated by four circular finishing cutters revolved by the flue, two of them being provided with length teeth and two with cross teeth, and placed adjustable on the same incline plane to the extending plate. Having the circular cutters on the revolving shafts on the same incline plane, the first and second cutters on each shaft will not come in contact with the flue but will afford an easy entrance, acting like a mill, preventing the machine from choking; there is no sticking, as the cutters are all revolving. To overcome oval places or uneven diameters, the cutters are arranged to give a little, and when this is passed immediately come back to the original position, and by a slight movement of top hand-wheel the machine can be reversed (or stopped) and the bad place cleaned by passing back and through again. Many flues are not perfectly straight, but as any part of them within the machine is held central in line the projecting ends are at liberty to swing.

The shafts are protected from dirt and dust with bronze bushings, that can be replaced; the cutters are made in duplicates, which can be furnished when desired, and the gears are all cut from the solid. The platform of frame is shaped like



a saddle to allow the loose lime to fall off freely. The speed of the machine is optional with user; the pulley can be run as high as 400 revolutions per minute, when about 8 or 10 feet per minute will be cleaned. Flues from 1½ to 3 inches in diameter can be cleaned. The machine requires floor space only 36 by 26 inches.

H. B. Underwood & Company, Philadelphia, Pa., are the manufacturers.

Personal

Mr. C. E. Lester has resigned his position as general foreman boiler maker of the Erie Railroad at Meadville, Pa., and has accepted the position of assistant master mechanic of the Baltimore & Ohio Railroad, with headquarters at Pittsburg, Pa.

Mr. J. Hughes, formerly boiler inspector for the United Fruit Company, with headquarters at Nipe Bay, Preston, Cuba, has resigned that position to become the general foreman of the United Fruit Company's locomotive department at Nipe Bay.

Mr. J. McAllister, formerly foreman boiler maker of the D. L. & W. Railway Company at East Buffalo, N. Y., has accepted the position of general foreman boiler maker for the Eastern Division of the Erie Railroad, with headquarters at Jersey City.

Mr. Charles H. Bowes writes The Boiler Maker that he has just returned from Detroit, Mich., where he has put up for the Connery Boiler Company of Philadelphia, Pa., what is claimed to be the largest smoke flue in the world. Mr. Bowes tells us that this flue covers three boilers of 2,500 horsepower each, belonging to the Edison Electric Company of Detroit, and that it took him three months to put it up.

Communications of Interest from Practical Boiler Makers

Applying Locomotive Boiler Tubes

Sometime ago I wrote about how I apply my flues to get good service. As I am not set in my ideas about applying flues to get good results, now I want to tell you how I now apply them to get better results.

I use the best quality iron flue, swedge same by machine, anneal the flue and clean thoroughly the end of the flue which goes to the fire-box side. I use copper 5/8 inch wide, allowing 3/32 on the water side for a joint. I roll all coppers. We enter all flues, setting them with a gage. After all flues are set to gage, we use a long stroke hammer to mandrel flues. This mandrel is of our own make. Most shops nip the flue with a hand hammer, but we do not want a hammer applied to the flue in fire-box end. This mandrel just opens up the flue slightly and the flue will not work inward. It takes us about an hour and a half to mandrel flues. We used to roll flues in the fire-box end, and it was not very long ago, if you will look back at my previous writing. We used to expand our flues any old way, just to get a tight job, as we thought. After all flues are mandreled we mark off the flue sheet similar to a cross, using two rows of flues for up and down, also two rows across from side to side, then divide the four corners to meet the center of the cross, using one row of flues for the division. Then take a circle of flues, using two rows equal distance from center of cross to sides top and bottom. Thus the flue sheet is marked.

After the flues are mandreled and sheet marked off as above, we pick out fifteen to twenty flues to use to hold both flue sheets rigid and diminish the vibration on account of using the long stroke hammer. We use a blind sectional expander to each flue, turning the expander once. We start from the center of the flue sheet and follow lines marked up and down and across first of all. Then we turn over the flues ready for beading and apply the sectional expander with the heel good and hard once, and then we follow all the other lines in a similar way. After all flues are expanded once we then go back and start all over again, using a sectional expander with heel, expand each flue twice more, not driving the expander as hard as in the first operation, and then examine each flue to see that it is perfectly smooth in the joint made by the expander. Then we calk the flue. We have put all our rollers away and allow no one to use a roller in the fire-box. I have increased the length of life of the flues from two to six months in the past, and now from seven to nine, and in better water districts I hope to get twenty months where I had only twelve to fifteen months.

This is nearly the same way some one is doing now, as I note in the past few months. Of course, I got my idea from others, but I just want to let you know if it was not for THE BOILER MAKER I would not be doing as I have stated above, and would not be giving satisfaction to my superiors if I did not try to be up to date and look for little things to give life to the boiler.

In roundhouse work I exclusively use the blind sectional expander with surprising success. As fast as we renew flues we issue orders never to use a beading tool in the roundhouse, except from special order from me. Only on our big engines do we use beading tools, and very little at that, and then only a few which show signs of the bead opening up. On all small engines I have never used a beading tool since applying flues as above. One engine to which I have referred has been in service seven months and leaks more or less every trip, but I have not used a beading tool on one flue in this time of seven months, and never had a delay on account of leaky flues on the road.

I have only one district where we have good water, but we only use one engine, and that a passenger. Other trains run part way over this line, but turn over to another line and get bad water, and I have to wash every trip or have a foamy boiler and leaky flues. But with care and patience, and the way I now apply flues, I hope to get excellent service. The engine above mentioned is on this run. Before this five or six months we renewed flues more on account of no beads than on account of flue delays and failures on account of not knowing how to work flues at terminals.

If it was not for THE BOILER MAKER, and those who write therein their ideas, standards, in fact anything about the boiler, I would say it could not be done; that is, keep flues in good condition, better than in the past, no matter if the boiler is bigger, has more pressure, etc.

From my experience I have increased the life of the flues in my district from two months to six and seven, and with other types of boilers and water conditions from six to fifteen, and I have not the best of conditions to work under, as anyone will tell you that has worked down in Old Mexico. But again I say THE BOILER MAKER has been a big help to me, and a little patience has helped me wonderfully.

Why don't more of the craft write a little article once in a while? Every little helps, and you may be helping some young man to a high position in this trade of boiler making.

Personally I am not way up on the theory of laying out boilers, designing, etc., but I can get something more than the designer could accomplish, and THE BOILER MAKER has done most of the work by having men give their ideas, experiments, shop kinks, tools used, etc., and these have been of excellent use to me, with something I have added here and there.

Monterey, Mexico. D. L. AKERS.

[EDITOR'S NOTE:—The above contributor wishes to know how to keep a set of flues tight more than five or six months without using boiler compounds or a filter of any kind to treat the water. The engine leaves the terminal with excellent water, and half way up the hill they use water which flows over a big body of zinc, copper and alkali. This water is as clear as crystal, but no one will or can drink the water. This water has a serious effect on the boiler, especially the flues, which leak as soon as this water is injected into the boiler. It forms a scale and quickly fills up the boiler and leaves a coat of scale on the crown sheet. He says that they get five to six months out of these flues before renewing, and the way they now apply flues gives better success than ever before. If any of the readers can throw some light on this subject it will be of great help not only to our correspondent but to anyone else who meets the same difficulties.]

"Sayings and Ten Rules" of Cyrus Simmons

While on a recent trip through the Central West I came across the "Sayings and Ten Rules" promulgated by Cyrus Simmons, one of the most famous captains of industry of his time. Will you kindly publish them in THE BOILER MAKER for the inspiration and benefit of the many earnest young men now engaged in business? It seems to me it wouldn't harm some of the older men to peruse them also. The "Sayings and Rules" are as follows: H. N. D.

THE "SAYINGS"

You can't be coddled into strength.

Vigor grows out of rigor.

It takes a hard task-master to secure efficiency. An indulgent coach is always a poor trainer.

It's a kindly whip that stings a man to greater effort.

Development is only possible through experience and experience is an unbending teacher. She flays her lessons home, but the graduates of her school are thoroughly taught.

If you resent authority, you stand small chance of assuming it.

If you really want to be right, you can't possibly object to regulations which insist that you shall do right.

You may have a good brain, a clear vision, a dogged will, deft hands and far-flung courage, but you can't utilize your gifts to the best advantage until some one who knows better has shown you how to handle them properly.

You're not fit to control until you have accepted control. You're not qualified to issue orders before you understand how to receive them. While you're a private in the ranks, obey without question. The shortest cut to command is implicit observance of commands.

If you're destined to do extraordinary things, there's no easier way proving it than your competent handling of ordinary situations.

The habit of being regular and prompt and accurate is the habit of success.

"THE TEN RULES"

No. 1—You can't impress me with your clothes. It's an old trick of the trade to hide inferiority with a coat of paint.

No. 2—Your work must more than cover your wages. I can't meet my bills if your job envelope doesn't total more than your pay envelope.

No. 3—The last time I did business with a friend, he took double measure and paid half price.

No. 4—I want a day's work for a day's pay. You can't explain when I complain. There's no market for excuses. Produce or cut loose.

No. 5—When I ask, give me the straight truth. I'm getting more than enough flattery from my enemies.

No. 6—It takes a lot of time to be an expert on any subject. You can't possibly be an authority on the fashions and follow the latest styles in work.

No. 7—The minute I know things don't suit you, you don't suit me. I can get more out of a blockhead than a sorehead.

No. 8—When you're satisfied with your success, I'll search for your successor. The only way to make sure of your place is not to feel sure of it.

No. 9—While you take my pay you must take my say. I pick my thoughts, not my words. My ideas, or you go.

No. 10—If your work does not show your age, I don't care a tinker's damn if you're gray-haired. I buy what's in your head, not what's on it.

A Word of Warning

I have just been reading that interesting article from the *Locomotive* which appears on page 360 of the December issue of THE BOILER MAKER entitled "Making Repairs Under Pressure," and would say that it is too bad that more of the men who work around and about steam plants do not know how close they really are to extreme danger. I fully believe that the reason they are not prepared for the possibilities in the line of so-called accidents is because such men seldom ever read technical magazines like THE BOILER MAKER, which are always sounding a warning note against doing things which should not be done, and, as well, leaving things undone that should be done, if human life is to be safeguarded. If technical papers were more widely read there would be less lives lost than occurs at present, for we seldom pick up a copy of an engineering paper that does not contain something of an instructive nature relating to the prevention of all kinds of happenings with steam boilers and piping.

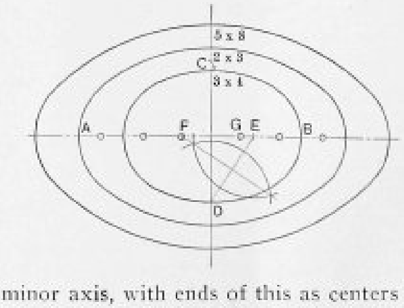
Not long ago, in this very city, a number of men were sent to take off a blank flange from a 22-inch exhaust line in a large electric lighting and power plant. A new engine unit had been installed and its exhaust-pipe was to be connected in the common main for all the engines. The work was to be done on a Sunday morning when the load on the station was light. The men—five of them—were given to understand by "some one" that the 22-inch main exhaust line was "dead," and that it was safe for them to take off the blank flange. After events show that whoever the "some one" was, his statement that the line was dead was not true. The pipe is in a trench, reached by the use of a ladder. One could hardly conceive of a worse place to be caught in escaping steam. The men, believing that the pipe was really dead, and presuming that everything was all right to go ahead with the job because their superiors had ordered them to do so, got down into the trench, and moved the ladder out of their way in order to have full swing at the flange. The nuts were taken off the bolts—*all of them*. A smart tap of the wrench caused the flange to fly off with force enough to kill the man who was *standing directly in front of it*. The other four were almost scalded to death, for they could not escape the outpouring steam. Their cries attracted the attention of the station watch engineers, who shut off the steam—after one man had been killed outright, and the other four had been parboiled. A second victim died the next day, and the others are still in the hospital. Of course, it was nobody's fault! But, how many men who make a practice of reading technical papers intelligently would have taken off that flange in that way? It is safe to say, *not one*. CHARLES J. MASON.

Scranton, Pa.

Marking Out Boiler Manholes

Prior to the introduction of elliptical trepanning tools boiler manholes were usually struck out as parts of circles. It is probable even now that in some of the smaller and more poorly equipped shops an oval hole is still marked out in this way.

The usual method, having scribed two lines at right angles and set off the necessary lengths, is to set trammels to total



length of minor axis, with ends of this as centers two arcs are described. Closing arcs with their centers along major axis are found by guess.

Centers for the closing arcs can be found by the following method: From extremity of major axis, with trammels still set to length of minor, mark off length. Join extremity of minor with line to point found. Bisect this line at right angles. Where bisection line cuts major axis is the center of closing arc.

The sketch makes the construction quite plain. In the proportions of 2:3 the shape is so close to true elliptical form that the difference is negligible. A. L. HAAS.

London, England.

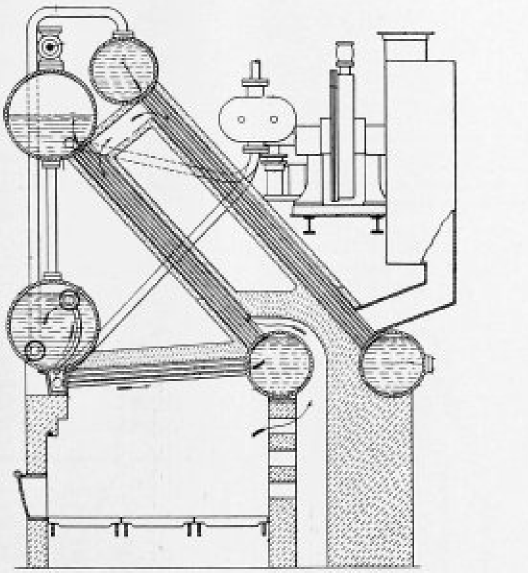
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,003,095. SODA STEAM GENERATOR. RAYMOND D'EQUEVILLEY-MONTJUSTIN, OF KIEL, GERMANY.

Claim 1.—A soda steam generator for submarine boats, provided with a steam generator of circular cross-section built into a soda container, said steam generator being constructed similarly to a ship's water-tube boiler, with narrow tubes, and comprising a plurality of water contain-



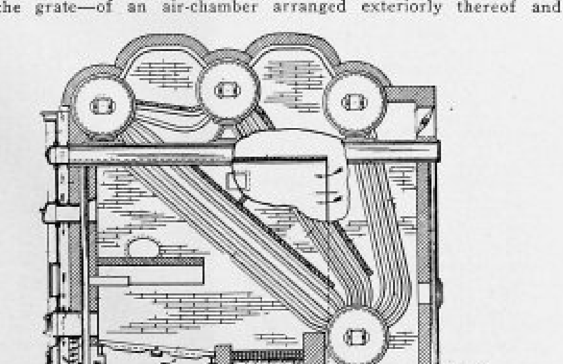
ers, horizontally disposed, and with their axes parallel to each other and to the axis of said soda container; said curved narrow tubes adapted to connect the water containers; opening into the sides thereof and being disposed in groups; and said water containers projecting through at least one end of said soda container. Two claims.

1,004,073. FURNACE. JAMES BROKENSHA POMEROY AND JOHN POMEROY, OF EAST ST. KILDA, VICTORIA, AUSTRALIA.

Claim 1.—In furnaces, an air bridge comprising a plurality of bars, each of said bars being provided with upper and lower laterally extending spacing nibs whereby, when t..e bars are assembled, air passages will be formed between adjacent bars, the upper surface of each of said lower nibs being inclined rearwardly and downwardly and extending beyond the rear wall of its associated bar to form a deflector. Five claims.

1,003,548. SETTING FOR BOILER FURNACES. HAYDEN HOMER TRACY, OF BERKELEY, AND HARRY EUGENE BOYRIE, OF SAN FRANCISCO, CAL.

Claim.—In a furnace—the combination with the main front wall of the setting having a damper-controlled air-draft-inlet to a point underneath the grate—of an air-chamber arranged exteriorly thereof and



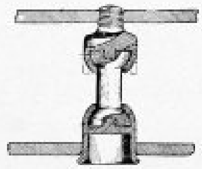
having a cold-air opening at its upper portion—and supplementary air chambers at the sides of the setting in communication with said front air chamber and open at their rear for receiving cold air from the exterior—the whole being adapted to recover waste heat radiated from the furnace walls, and apply same to pre-heat the air used to promote combustion in the furnace.

1,003,792. REGULATION OF THE TEMPERATURE OF SUPERHEATED STEAM. JOHN PRIMROSE, OF DANSVILLE, N. Y.

Claim 2.—In means for regulating the temperature of superheated steam, the combination with a superheater having an inlet header; of means for spraying water directly into each of the superheating tubes connected with said header; as set forth. Five claims.

1,003,705. STAY-BOLT. EDWARD W. CLARK, OF LOS ANGELES, CAL.

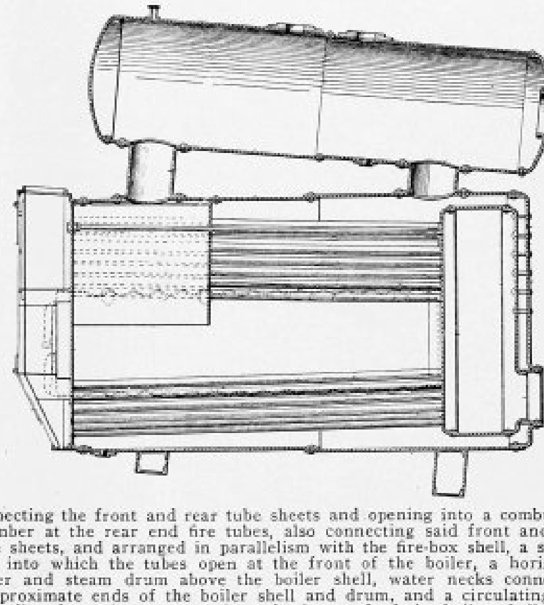
Claim 2.—A flexible stay-bolt comprising a central shaft having enlarged ends; and thimbles mounted upon said enlarged ends by swag-



ing, and adapted to oscillate, but not rotate thereon, said thimbles being adapted to be secured in the respective parts united by the bolt. Three claims.

1,003,776. STEAM BOILER. JOSEPH ALEXANDER MUMFORD, OF ROSLYN, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO ROBB-ENGINEERING COMPANY, LIMITED, OF AMHERST, CANADA, A CORPORATION.

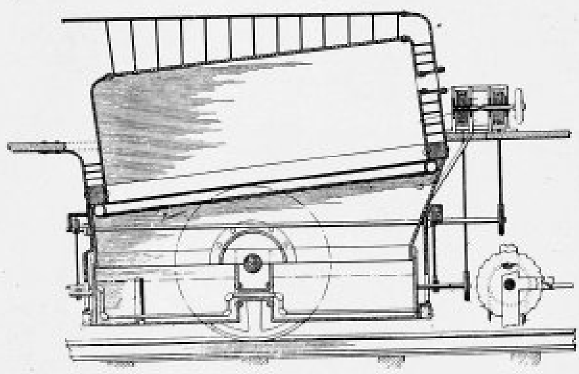
Claim.—In an internally-fired boiler the combination of the boiler shell inclined upwardly from front to rear, the internal fire-box shell



connecting the front and rear tube sheets and opening into a combustion chamber at the rear end fire tubes, also connecting said front and rear tube sheets, and arranged in parallelism with the fire-box shell, a smoke-box into which the tubes open at the front of the boiler, a horizontal water and steam drum above the boiler shell, water necks connecting the proximate ends of the boiler shell and drum, and a circulating pipe extending from the water neck at the low end of the boiler shell down between the upper fire tubes and the fire-box shell.

1,003,992. LOCOMOTIVE ASH-PAN. ISAAC A. DAVIS, OF GRAND ISLAND, NEB., ASSIGNOR OF ONE-HALF TO HANS P. HANSEN, OF GRAND ISLAND, NEB.

Claim 1.—In a locomotive ash-pan, the combination with a hopper adapted to receive the ashes from the grate, of a shiftable and rockable



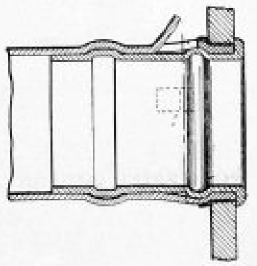
ash-pan adapted to receive the ashes from the hopper, means for raising and lowering the ash-pan in relation to the hopper, and means for rocking the ash-pan. Seven claims.

1,003,297. WATER-TUBE BOILER. FRANK R. SARTOR, OF MUNCIE, IND.

Claim.—A water-tube boiler comprising an outer shell embodying top, bottom, side and end walls, the bottom wall and one of the end walls having openings therein, an inner shell similarly constructed, the upper portion of said inner shell being inclined at an oblique angle to the outer shell, a ring disposed between and secured to the bottom walls of said shells and forming a grate support, a grate fitted within the bottom opening of the inner shell and resting on said support, a fuel inlet tube connecting the openings in the end walls of said shells, inclined water tubes extending through the inner shell and communicating with the outer shell and supported by the end walls of said inner shell, a steam dome rising from the top of the outer shell and having a contracted upper end, a smokestack extending from the top of the inner shell and through said steam dome and connected with the contracted portion thereof, said stack being of less diameter than the body portion of the dome, and a steam exhaust pipe leading from the contracted portion of the dome.

1,004,310. DEVICE FOR REPAIRING BOILER FLUES. HENRY J. TIBBENS, OF DANVILLE, ILL.

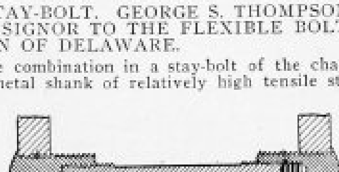
Claim.—The combination with a boiler flue having vent openings near the end, of a thimble extending into said flue and beyond the vents and



with an outwardly directed bead at the outer end adapted to engage against the flue sheet, said thimble being further beaded between the vent opening and the flue and also near its inner end, whereby the flue material is pressed outwardly and spaced slightly from the thimble to provide for circulation of water between the flue and thimble.

1,004,937. STAY-BOLT. GEORGE S. THOMPSON, OF HOCKESSIN, DEL., ASSIGNOR TO THE FLEXIBLE BOLT COMPANY, A CORPORATION OF DELAWARE.

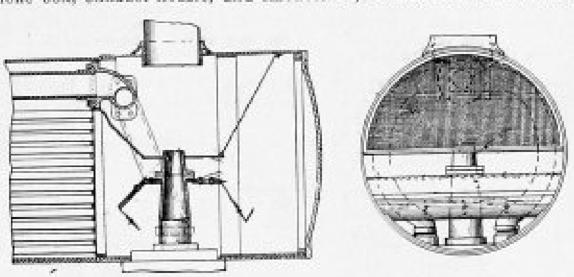
Claim 1.—The combination in a stay-bolt of the character designated, of a threaded metal shank of relatively high tensile strength and small



diameter formed with a tell-tale bore in its inner end, an externally threaded socket head of less tensile strength formed with a female thread extending through said head for engagement with the male thread on the shank, and a screw plug engaging said female screw thread and closing the end of said head. Seven claims.

1,004,851. ADJUSTABLE CLEANER AND SMOKE CONSUMER FOR LOCOMOTIVE SMOKE-BOXES. WILLIAM E. COONEY, OF CLEVELAND, OHIO, ASSIGNOR TO JULIA LA FRAMBOISE, OF LAKEWOOD, OHIO.

Claim 3.—The combination with a locomotive boiler and flues therefor, a smoke box, exhaust nozzle, and smokestack, of a horizontal screen and



a parallel plate forming a horizontal passage in the smoke-box, deflecting plates adapted to direct the draft from the central and upper flues to said horizontal passage, deflecting plates adapted to direct the products of combustion from the lower flues to the front of the smoke-box, and a screen between the front of said smoke-box and said smokestack and connected with the screen first mentioned, the said deflecting plates having horizontal movement permitting the size of the passages to be varied. Six claims.

1,004,315. TUBULAR BOILER. JEAN VAN WOSTERWYCK, OF LIEGE, BELGIUM.

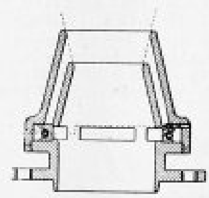
Claim 1.—In a steam generator, the combination with a plurality of drums arranged one above the other, of steam and water tubes connecting adjacent drums to conduct steam from the lower to the upper drum and water from the upper to the lower said drums, said tubes being so arranged that the water entering the lower drum is caused to move through the body of steam passing through the steam space of said drum to the drum above. Eight claims.

1,004,896. SAFETY APPARATUS FOR STEAM BOILERS. HARRY NEVILLE, OF LOS ANGELES, CAL., ASSIGNOR OF ONE-FIFTH TO GEORGE H. GOODWIN, ONE-FIFTH TO DANIEL P. KELLOGG, ONE-FIFTH TO WILLIAM F. MERRY, AND ONE-FIFTH TO PATRICK SHEEDY, ALL OF LOS ANGELES, CAL.

Claim 1.—The combination with a steam boiler, of an alarm, a pipe leading from the steam space in the boiler to the alarm, a valve in said pipe, a coupling in said pipe beyond said valve, a cut-off beyond the said coupling disposed normally at one side of said pipe, a pipe leading from said coupling to said cut-off to admit steam thereto whereby to project it across the first-mentioned pipe, a pipe leading from said coupling to the fire-box of the boiler, a valve arranged adjacent the fire-box to be actuated by the steam passing through said pipe to control the combustion, a steam casing on the boiler and communicating therewith, and a heat responsive element in said casing to operate first-mentioned valve. Three claims.

1,004,770. EXHAUST NOZZLE FOR LOCOMOTIVES. JOHN L. GALLOWAY, OF VALLEY JUNCTION, IA., and THOMAS GALLOWAY, OF CORLISS, WIS.

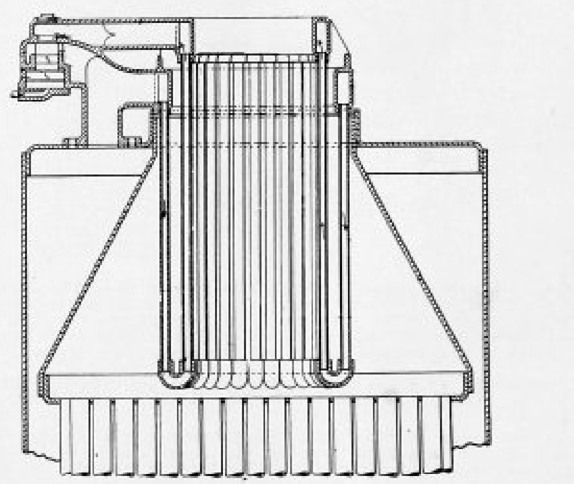
Claim 1.—An exhaust nozzle for locomotives, consisting in the combination of inner and outer nozzle casings having their lower portions



connected with each other and their upper portions tapered inwardly and constituting steam passages of different size, the outer casing being extended beyond the inner casing and provided with a larger discharge orifice forming a common outlet for both passages, and the inner wall being provided with ports affording communication between the inner and outer passages. Four claims.

1,004,713. STEAM BOILER. CHARLES W. TODD, OF MANCHESTER, N. H.

Claim 1.—In combination a boiler having a steam space and steam delivery pipe provided with a controlling valve and a superheater inter-



posed between said steam space and steam delivery pipe, a by-pass for placing said steam space in direct communication with the delivery side of said superheater, and means for automatically closing said by-pass when the throttle is open and opening it when the throttle is closed. Five claims.

1,004,706. STEAM GENERATOR. DAVID STARK AND ARTHUR R. CARLYLE, OF SAN FRANCISCO, CAL.

Claim 2.—A water-tube boiler comprising inclined front and rear water legs having substantially parallel sides, a substantially horizontal steam and water chamber above said water legs and connected thereto by rounded corner portions having substantially concentric sides, water tubes connecting said water legs and arranged normal thereto, a steam drum above said steam and water chamber, tubular connecting members between said steam and water chamber and said steam drum, a fire chamber below said water tubes, and a plurality of relatively small fire tubes extending through said steam and water chamber and adapted to convey the products of combustion to a smoke chamber above said steam and water chamber. Three claims.

1,003,228. LOCOMOTIVE-FURNACE DEVICE. JOHN BOLGIANO, OF BALTIMORE, MD.

Claim.—The combination of a thin, flat drum mounted vertically within the furnace parallel to one of its walls, but spaced therefrom and having a laterally projecting foot at its lower end extending toward the fire and overlapping the grate, and closing the space between the drum and the grate, the drum having water tubes connecting it with the boiler so as to maintain a water circulation therethrough, the channel formed between the drum and the wall behind it being in communication with an air supply and delivering heated air to the upper part of the fire chamber.

1,003,005. BLOWER FOR BOILERS. ALFRED G. MATTSSON, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY COMPANY, OF DETROIT, MICH., A COPARTNERSHIP.

Claim 1.—The combination with the breech-door of a boiler, of a blower comprising a pipe extending through said door and having jet-openings, and means for rotatively supporting said pipe in said door. Three claims.

THE BOILER MAKER

FEBRUARY, 1912

Calculations for the Bracing of Flat Surfaces in Boilers

BY J. P. MORRISON

"No brace shall bear greater strain than 7,500 pounds per inch of cross sectional area, and care will be exercised that all braces bear uniform tension. * * * The workmanship will be the best skilled men, improved machinery and years of experience can produce."

The foregoing paragraph has been copied from the horizontal tubular boiler specifications of a prominent boiler manufacturing concern, and in more or less modified form may be found in the specifications used by the majority of boiler builders.

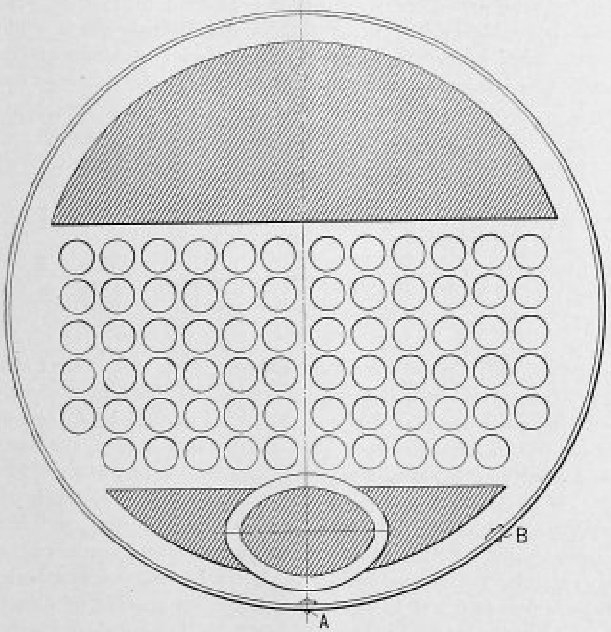


FIG. 1

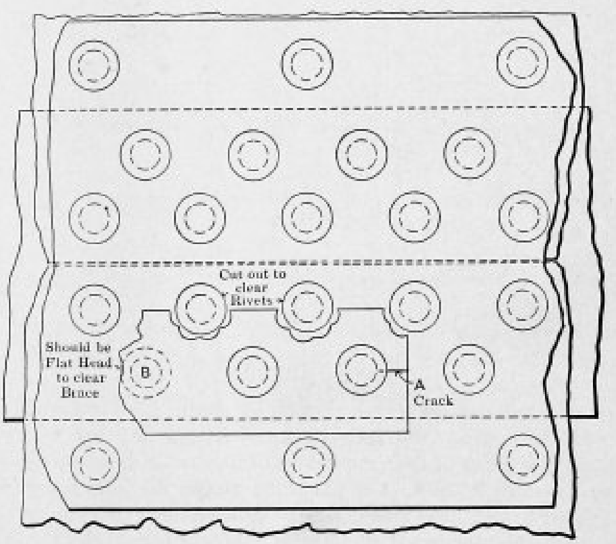


FIG. 2

The "safe load" on braces per square inch of cross sectional area varies in different localities and with different authorities, but the general allowance is 7,500 pounds where no law or regulation prevents.

It is also customary, and in some States lawful, to consider the boiler head as rigid a distance of 3 inches from the head flange and 2 inches from the tubes, and not in need of bracing. The remaining area—called the "area to be braced"—is shown by shaded portion of Fig. 1, and Table I gives the area in square inches to be braced in boilers of different diameters and segments of various heights. This table covers the range of boilers met in general practice. The diameters and heights given are actual, while the values for the area are net, or "area to be braced."

Tables II, III and IV give the safe load at 7,500 pounds per square inch upon braces made of standard sizes of material as found in general practice. The size of the foot and blade is also given for round braces, together with the size of rivet holes necessary, the rivet being considered as filling the hole when driven. The foot or end of brace riveted to the boiler head must have one and one-third times the strength of the brace proper, according to modern requirements, and the sizes given in the tables are the nearest commercial size having that strength after the holes are punched. In order to briefly illustrate the use of the tables, a horizontal return tubular boiler, 72 inches in diameter with seventy 4-inch tubes and designed to carry 150 pounds pressure, will be considered in the following:

The standard distance from the upper row of tubes to the outside of head flange is 27 inches, which, as will be seen by referring to Table I, gives an area of 998 square inches to be braced. At 150 pounds pressure per square inch the braces will carry a load of 149,700 pounds. If braces 1¼ inches in diameter are used each brace will support 9,203 pounds, and seventeen will be needed to each head. However, should there be a manhole opening 11 inches by 16 inches in the rear head, and Ohio or Massachusetts law be followed, 95 square inches may be deducted from the area to be braced as an allowance for the stiffness of the manhole reinforcement, and but fifteen braces would be required to the rear head.

These 1¼-inch braces should have blades 3 inches by ⅝ inch and ⅞-inch rivets, driven in 15/16-inch holes. The foot of each brace should be made of 2½-inch by ½-inch material, as shown in Table II.

The segment below the tubes is 16 inches high and area to be braced is 374 square inches, from which 91 square inches may be deducted for the reinforcing ring of 10-inch by 15-inch manhole opening, leaving an area of 283 square inches of front head to be braced.

Through rods are in common use for bracing the heads below the tubes. Four 1⅜-inch diameter would be needed for the front head and two 1¼-inch diameter crowfoot braces

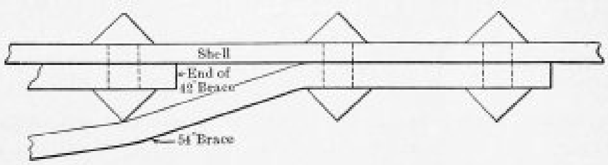


FIG. 3

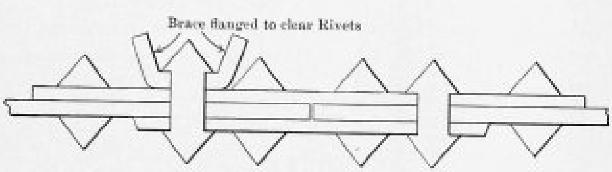


FIG. 4

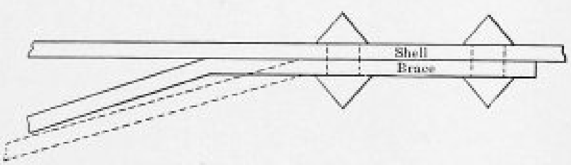


FIG. 5

would be added to the rear head on account of the greater area needing braces.

The 1⅜-inch through-rods should be upset at front end to 1½ inches diameter and threaded five and one-half threads per inch.

The jaw at rear end should be formed of 2¾-inch by ⅝-inch or 3-inch by ½-inch material, and the foot of same size is riveted to the rear head with two 1-inch rivets driven in 1 1/16-inch holes. The pin bolt securing the jaw to the foot should be 1⅛ inches in diameter and nearly a driving fit.

Some builders weld the foot at the rear end to the through rod, thus eliminating the jaw and pin bolt.

In boilers of the marine type the through rods above the tubes extend through each head. They are upset at each end, in which case neither jaw, pin bolt nor foot is used. But when the rear end of the through rod is below the fire line, as is the case with braces at sides and between the furnaces, the practice of using nuts at rear has practically been abandoned for the use of the foot and jaw. The foot is often separated from the head to which it is riveted by thimbles about 1 inch long, through which the rivets pass.

These jaws and crowfeet are in most cases made of ½-inch boiler plate, and the sizes given in the tables are for that thickness.

If the foot is made to measure 12 inches from the boiler head to the pin bolt, there is the advantage of being able to remove a broken rod easily.

Of the older boilers it is sometimes necessary to have additional braces put in to make them meet modern requirements, but most boilers built in recent years have a sufficient number of braces of proper size. However, concerning the "uniform tension and workmanship" as much cannot be said.

The value of the braces is often impaired when the boiler head is laid out. The distribution of braces over the surface to be supported should be uniform, and this can be done with an ordinary amount of care. The standard layout is generally used to front heads, but in boilers having a manhole opening in the rear head the braces are often distributed in haphazard manner over the area remaining after the manhole flange is turned without thought of braces next to the opening having an extra load to carry, owing to lack of bracing in area occupied by the manhole plate. In some instances the use of larger and stronger braces on each side of the opening is advisable. Usually, and especially in boilers of large diameter where there are several braces to each head, the braces are of three or four lengths—42 inches, 48 inches, 54 inches and 60 inches. When the rivet holes in the shell plate for the blade of a 54-inch brace are located along the same longitudinal line as a 42-inch brace, the 54-inch brace will ride the rivet in the end of the blade of the 42-inch brace as shown in Fig. 3. The braces should not follow the same longitudinal line.

In many shops, including some of the oldest and largest in the country, it is the practice to use the seam rivets for holding as many brace blades as possible. Aside from throwing an extra strain on the seam rivets this practice often causes unlimited trouble. Recently a boiler was built of ¼-inch plate with a double-riveted lap seam, having ⅝-inch rivets. The braces used were 1¼ inches in diameter, and blade of one brace to each head was located in the seam. In this way two ⅝-inch rivets were used to hold a 1¼-inch diameter brace

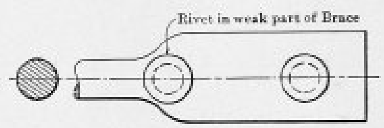


FIG. 6

when ⅞-inch rivets should have been used. Of course, the brace is no stronger than the rivets. The rivet in the seam next to ones used for holding the brace should be driven on the inside in a countersunk hole. If this is not done, the brace will ride the rivet head and will not fit up. When brace blades are located in the seams of a butt-strapped boiler, the heads of the rivets in the adjoining rows are in the way, and it is common, but poor, practice to cut away part of the brace, so it will clear these rivet heads, as shown by Fig. 2. The boiler maker does not care to punch half holes, on account of danger from breaking punches, so is liberal of the metal and often very little stock is left.

There is little or no excuse for the practice of locating the braces in the seams, and, considering the extra labor, nothing is saved. In lap-seam boilers there should be no trouble in keeping the braces out of the seams, and to do so where butt joints are used requires only the use of two or three longer braces to each head, so they will reach to the second course from the head. Or the braces which, if placed radially, would fall in the seam, may be run at an angle which will carry them above or below the seam.

If there is any local reason for locating the braces in the seam the blade should not be cut to clear the adjoining rivets, but should be flanged, as shown in Fig. 4.

Another very common defect is shown in Fig. 6, where the brace was made too long and holes were punched where marked, regardless of one coming in the tapered part of the blade and leaving little metal.

The practice of putting a "kink" in a brace when too long is, of course, universally condemned, and upsetting to shorten, or discarding for one of proper length, as should have been done in case of Fig. 5, is the proper remedy, but there are

TABLE I.—AREAS TO BE BRACED IN SQUARE INCHES.

Height Seg.	Diameter. 36 Ins.	42 Ins.	48 Ins.	54 Ins.	60 Ins.	66 Ins.	72 Ins.	78 Ins.	84 Ins.	90 Ins.
12	125	139	152	163	174	185	194	203	212	....
13	151	168	184	198	212	225	235	248	258	....
14	178	199	218	235	251	266	279	294	306	....
15	206	231	253	273	292	310	326	343	357	373
16	235	264	289	313	335	356	374	394	411	428
17	264	297	327	354	379	403	424	447	467	485
18	....	331	365	396	425	452	476	501	524	545
19	....	366	404	439	471	502	529	557	583	607
20	....	401	444	483	519	553	584	615	643	671
21	....	....	485	528	568	606	640	674	705	736
22	....	....	526	574	618	659	698	735	769	803
23	....	....	567	620	668	714	756	796	834	871
24	....	....	....	667	720	769	815	859	901	941
25	....	....	....	714	772	825	875	923	968	1012
26	....	....	....	761	824	882	936	988	1037	1084
27	....	....	....	....	877	940	998	1054	1106	1157
28	....	....	....	....	930	998	1061	1121	1177	1231
29	....	....	....	....	984	1056	1124	1188	1249	1307
30	....	....	....	....	....	1115	1188	1257	1321	1383
31	....	....	....	....	....	1175	1252	1326	1394	1460
32	....	....	....	....	....	1235	1317	1395	1468	1538
33	....	....	....	....	....	....	1382	1465	1542	1617
34	....	....	....	....	....	....	1447	1535	1617	1696

Height Seg.	Diameter. 96 Ins.	102 Ins.	108 Ins.	114 Ins.	120 Ins.	126 Ins.	132 Ins.	136 Ins.	138 Ins.	144 Ins.
12	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	....	....	....	....
14	....	....	....	....	....	....	....	....	....	....
15	....	....	....	....	....	....	....	....	....	....
16	....	....	....	....	....	....	....	....	....	....
17	....	....	....	....	....	....	....	....	....	....
18	565	587	606	625	644	662	680	692	698	713
19	629	654	675	696	718	738	778	772	778	794
20	695	722	746	771	794	816	838	850	860	878
21	763	793	819	846	871	900	921	933	945	965
22	833	865	895	923	951	983	1006	1026	1033	1055
23	904	940	972	1003	1034	1068	1093	1119	1122	1147
24	977	1015	1050	1085	1117	1155	1182	1209	1214	1241
25	1051	1092	1130	1168	1203	1243	1273	1292	1307	1337
26	1126	1171	1212	1252	1290	1333	1366	1398	1403	1435
27	1203	1251	1295	1339	1379	1425	1461	1490	1500	1535
28	1281	1333	1380	1426	1470	1519	1558	1590	1599	1636
29	1360	1415	1465	1515	1562	1614	1656	1688	1700	1738
30	1440	1499	1553	1606	1656	1711	1756	1788	1803	1843
31	1521	1584	1641	1698	1751	1809	1857	1885	1907	1950
32	1603	1670	1731	1791	1847	1908	1960	2000	2012	2058
33	1686	1756	1822	1885	1945	2009	2064	2101	2119	2168
34	1771	1844	1913	1980	2044	2112	2170	2208	2228	2280

TABLE II.
ROUND CROW-FOOT BRACES.

Diameter.	Size of Foot.	Size of Blade.	Diameter Rivet Hole.	Safe Load 7,500 Pounds.
Inches.	Inches.	Inches.	Inches.	
3/4	1 3/4 x 1/2	2 x 1/2	13/16	3,312
7/8	2 x 1/2	2 1/2 x 1/2	13/16	4,509
1	2 x 1/2	2 1/2 x 1/2	13/16	5,890
1 1/8	2 1/2 x 1/2	2 1/2 x 5/8	13/16	7,455
1 3/16	2 1/2 x 1/2	2 3/4 x 5/8	15/16	8,300
1 1/4	2 1/2 x 1/2	3 x 5/8	15/16	9,203
1 3/8	2 1/2 x 5/8	3 x 3/4	15/16	11,136
1 1/2	3 x 5/8	3 x 1	1 1/16	13,253
1 5/8	3 x 5/8	3 1/2 x 1	1 1/16	15,554

FLAT CROW-FOOT BRACES.

Size.	Strength of Bar.	Diameter Rivet Hole.	Safe Load 7,500 Pounds.
Inches.		Inches.	
2 x 1/2	7,500	13/16	4,453
2 1/2 x 1/2	9,375	13/16	6,328
2 1/2 x 5/8	11,718	13/16	7,910
2 3/4 x 1/2	10,312	13/16	7,266
2 3/4 x 5/8	12,890	15/16	8,500
3 x 1/2	11,250	15/16	7,740
3 x 5/8	14,062	15/16	9,590
3 x 3/4	16,825	15/16	11,525
3 x 1	22,500	1 1/16	14,955
3 1/2 x 1/2	13,125	1 1/16	9,503
3 1/2 x 5/8	16,415	1 1/16	11,535
3 1/2 x 3/4	19,687	1 1/16	14,003
3 1/2 x 1	26,250	1 1/16	18,281

many kinked braces in boilers now in operation, and these are not all old boilers, and have not all been built in small shops, either.

In shops where well-established systems are used, standard lengths for braces and standard locations for rivet holes should be maintained, and kinked braces and those damaged otherwise through endeavors to make them fit should be unknown.

Another evidence of poor workmanship is found when rivet holes in the blade or foot of a brace are punched so near the edge the metal is cracked, as in Fig. 6.

The solid lines of the brace shown in Fig. 5 represent the location of the bend in the brace where riveted to the shell, as often seen. The proper place for this bend is shown by the dotted lines. It will be understood that the head supported by

TABLE III.
HUSTON AND MCGREGOR BRACES.

Size.	Sectional Area.	Diameter Rivet Hole.	Net Sectional Area.	Safe Load at 7500 Pounds.
Inches.		Inches.		
2 1/2 x 5/16	.7812	11/16	.565	4,227
2 3/4 x 5/16	.8593	11/16	.643	4,821
3 x 5/16	.937	11/16	.721	5,406
2 1/2 x 3/8	.938	11/16	.722	5,415
2 3/4 x 3/8	1.030	13/16	.726	5,445
3 x 3/8	1.125	13/16	.819	6,150
3 1/4 x 3/8	1.212	13/16	.907	6,801
3 1/2 x 3/8	1.312	13/16	1.007	7,551
2 3/4 x 7/16	1.212	13/16	.805	6,036
3 x 7/16	1.315	13/16	.905	6,786
3 1/4 x 7/16	1.425	15/16	1.015	7,611
3 1/2 x 7/16	1.535	15/16	1.125	8,436
3 3/4 x 7/16	1.645	15/16	1.235	9,261
4 x 7/16	1.755	15/16	1.345	10,086
3 x 1/2	1.5	15/16	1.033	7,744
3 1/4 x 1/2	1.625	15/16	1.158	8,685
3 1/2 x 1/2	1.75	15/16	1.283	9,621
3 3/4 x 1/2	1.875	1 1/16	1.334	10,080
4 x 1/2	2.	1 1/16	1.469	11,025
4 1/4 x 1/2	2.125	1 1/16	1.594	11,955
4 1/2 x 1/2	2.250	1 1/16	1.719	12,891

TABLE IV.—THROUGH RODS.

BACK END.

Diameter.	Area.	Safe Load 7,500 Pounds.	Size of Jaw and Foot.	Rivets. No.	Rivets. Hole.	Pin Bolt.
Inches.	Sq. Inches.		Inches.		Inches.	Inches.
1 1/4	1.23	9,203	2 1/2 x 5/8 or 2 3/4 x 1/2	2	15/16	1 1/8
1 3/8	1.48	11,136	2 3/4 x 5/8 or 3 x 1/2	2	1 1/16	1 1/.
1 1/2	1.77	13,253	3 x 5/8 or 3 3/4 x 1/2	2	1 1/16	1 1/4
1 5/8	2.07	15,554	3 1/2 x 5/8 or 4 1/4 x 1/2	2 or 4	1 1/8 13/16	1 1/4
1 3/4	2.41	18,039	3 1/2 x 3/4 or 5 x 1/2	2 or 4	1 1/4 15/16	1 3/8
2	3.14	23,592	6 x 1/2	6	13/16	1 1/2
2 1/4	3.98	29,820	7 x 1/2	8 or 6	13/16 15/16	1 11/16
2 1/2	4.91	36,317	8 1/2 x 1/2	10 8 6	13/16 15/16 1	1 7/8
2 3/4	5.94	44,546	10 x 1/2	12 9 7	13/16 15/16 1 1/16	2 1/16
3	7.07	53,014	11 3/4 x 1/2	14 10 8	12/16 15/16 1 1/16	2 1/4

FRONT END.

Diameter.	Upset. Diameter.	Upset. Number Threads.	Bottom of Thread. Diameter.	Bottom of Thread. Area.	Bottom of Thread. Safe Load 7,500 Pounds.
Inches.	Inches.		Inches.	Sq. Inches.	
1 1/4	1 1/2	6	1.28	1.38	9,600
1 3/8	1 5/8	5 1/2	1.39	1.52	11,475
1 1/2	1 3/4	5	1.49	1.75	13,200
1 5/8	1 7/8	5	1.62	2.05	15,275
	2	4 1/2	1.71	2.3	17,250
1 3/4	2 1/4	4 1/2	1.96	3.02	23,404
2	2 1/2	4	2.17	3.7	27,750
2 1/4	2 3/4	4	2.43	4.6	34,500
2 1/2	3	3 1/2	2.63	5.44	40,800
2 3/4	3 1/4	3 1/2	2.88	6.5	49,500
3	3 1/2	3 1/4	3.1	7.55	56,550

the brace bent, as shown by the solid lines, will bulge before the brace is under tension, while the brace shown in dotted lines is immediately in tension. The bend should be at the head of the rivet.

Unfair holes should never be found in the foot or blade of a brace, as at least one pair of holes is marked off in place, and all holes may be with very little additional cost. However, owing to careless handling of the center punch or careless punching, holes 1/8 inch to 1/4 inch "off" are not uncommon.

When the upper manhole is located in the rear head it is customary, and good practice, to rivet two braces to the head between the manhole opening and the upper row of tubes in boilers of 60 inches diameter and larger. These braces are about 12 inches apart where riveted to the head, and are often the same distance apart where riveted to the top of the boiler. This does not leave sufficient space for a man to pass between the braces. If the blades are 24 inches apart at the shell the opening is ample.

The braces to front head are often distributed so one or more is on the vertical diameter of the head, and the blades, if braces are extended radially, are riveted along the center line of the top of the boiler. In some boilers the top feed-water connection is located within a couple of feet of the front head, and in order to pass the center braces the internal extension of the feed pipe must be made up of short nipples and 45-degree elbows. If the location of the center braces, where riveted to the shell, is changed to either side, so as to clear the center line by 3 or 4 inches, the feed pipe may be extended without fittings of any kind and the layer-out would receive greater credit for mechanical skill. It looks really foolish to lay out a hole in the top of a boiler for the feed pipe, which must be extended to the waterline, and then locate a brace under the opening.

It has been freely conceded that a "boiler is not built like a watch," and that "the average boiler maker is not expected to understand the science of the industry"; but he should be well versed in the best practice of the trade.

The shop superintendent should be well informed on all subjects related to steam boiler engineering, and his supervision should be a check on defective work of all descriptions. In the shop too little attention is given to the art of doing things just right. There is too much "that-is-good-enough" feeling. A desire to furnish the article exactly as specified should be cultivated by all concerned, from president to rivet heater, and including, particularly, the persons responsible for statements made in prospectus and specifications.

The Evolution of the Scotch Marine Boiler

BY SINCLAIR COUPER

It is rather interesting to note how many types of boilers have received their distinctive names from the countries or districts in which they first appeared, or in which they were first most frequently used or manufactured. As prominent examples of this style of nomenclature in engineering, which curiously enough seems peculiar to boilers, we have the "Cornish" and the "Lancashire" boilers, while the Bouilleur boiler is frequently known as the French boiler. These "place-names," as we may call them, have come to be the recognized titles of the respective boilers, and when so used no further description is necessary to convey to our minds what boiler is meant.

Similarly the steam boiler which is the subject of the present article has come to be known as the "Scotch" boiler, because it was first introduced on the River Clyde, in Scotland, and because it speedily became the typical boiler for installation in practically all steam vessels built in that country.

Another name, and one which is perhaps more universally used for this type of steam generator, is simply the "Marine" boiler, owing to its use on board ship, to which purpose indeed its application for many years seems to have been almost entirely confined. Now there are many instances in which it has been installed for use on land and where it has given complete satisfaction.

On account of its external form it has often been described as the "Drum" boiler, and also as the "Tank" boiler.

Of a cylindrical shape, with flat ends, its chief feature is in the internal arrangement, consisting of one or more furnaces which lead into a combustion chamber, or chambers, placed near the back end and contained within the shell of the boiler. From these chambers, tubes of small diameter convey the products of combustion back to the front end of the boiler into a smoke box, from which they pass to the chimney.

Hence the boiler is correctly described as the "Cylindrical Return Tubular Boiler," for the appellation "Marine" does not sufficiently distinguish it from boilers of the Haystack, Locomotive and Direct Through Tube types, nor from boilers of the watertube type, all which are in use on board ship.

Owing to there being a water space between the back plate of the combustion chamber and the back end plate of the Scotch boiler it has frequently been described as the "wet back" boiler. This name, however, has become attached to the boiler through its descent from an earlier type, in which the back-water space was also a feature, and to which we shall refer later on.

The object of this article is to trace the evolution of the Scotch marine boiler from those types which preceded it in the history of steam navigation, and to show how it has been the result of a gradual development in design.

To do this, however, we must in the first place recall to mind some of the types of boilers which were used on land in the early days of the application of steam to industrial purposes, and before any attempt had been made to apply the steam engine to the propulsion of vessels.

The very earliest boilers were of the spherical shape, with the fire placed on a grate directly beneath them. Such a form, however, was very deficient in heating surface, as the largest amount of this that could be obtained would not be very much more than the grate area. It was natural, therefore, that efforts should be made to produce a design in which this defect would be remedied, and recourse was had to the vertical cylindrical type with a flattened or inverted bottom.

These early boilers were made of cast iron, but when wrought iron plates became available, and larger boilers were required, the vertical form was still retained, and some boilers of very large size were built of that shape. The vertical type ultimately gave place to the horizontal oblong type, having a flat or arched bottom, flat sides and a rounded top. This was the type of boiler which had been introduced by James Watt. On account of its shape it was known as the "Wagon" boiler, and was much used by Watt and others. It had a long career, and was greatly in vogue, even in Lancashire, down to about sixty or seventy years ago. Owing to its design it was totally unfitted for anything but very low steam pressures, and even at these it was exceedingly liable to change of form, in spite of the internal cross stays with which it was fitted.

The next step in the progress of design was the introduction of the horizontal cylindrical boiler with either flat or dished ends. When the ends were made of a hemispherical shape the boiler was known as the "Egg-End" boiler.

All these types had the fire placed underneath them, in a furnace external to the boiler, so that the flames and hot gases were in direct contact with the shell and passed along the bottom, from the front to the back of the boiler, and thence to the chimney.

This arrangement was improved upon by building side flues, formed by brick walls adjacent to the boiler, through one of which the gases from the bottom flue were compelled to return to the front end, across which they passed and entered the flue on the other side of the boiler, passing along it until they came to the outlet at the rear end leading to the chimney.

Another advance towards greater economy in the generation

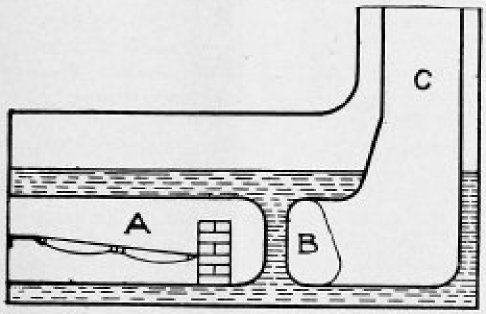


FIG 1

of steam was the introduction of a wrought iron flue or large tube within the boiler, through which the gases, after having traversed the external bottom surface of the boiler, were made to pass to the front end, where they were divided and then returned to the back end by means of external brickwork side flues. By this arrangement of having an internal flue a very large and valuable addition was made to the heating surface of the generator, and once introduced, this improvement has remained a feature in one form or another of all boilers belonging to what is known as the "firetube" type, in contradistinction to those types in which the water is contained within tubes, which are exposed to contact with hot gases on their external surfaces.

A further very notable improvement was the placing of the fire within the internal flue of the horizontal boiler. This brings us to the type known as the Cornish boiler, to which reference has already been made. This may be called the first of the internally-fired boilers, and its introduction marked another distinct and most important advance in boiler design, making for greater economy in the production of steam.

The above short and very incomplete account of the typical boilers in use up to the introduction of steam navigation may help us to realize more clearly what resources were available to the early experimenters in the propulsion of vessels by steam power. James Watt had joined Matthew Boulton in business at Soho, Birmingham, in 1773, and from that date there followed with a wonderful rapidity the various applications of the steam engine to pumping and other industrial purposes. The new source of energy, however, was not applied so quickly to the propulsion of vessels, although it must be borne in mind that Patrick Miller, aided by Taylor and Symington, carried out his first experiment with a steam-propelled vessel in 1788, on Dalswinton Loch in Scotland. This was only fifteen years after the date when Boulton and Watt began business at Soho; but, with the exception of Miller's second vessel, launched in 1789 and shortly afterwards laid aside, nothing further of any moment occurred until 1803, or thirty years after the date of Boulton and Watt's commencement, when Symington launched the small steamer *Charlotte Dundas* on the Forth and Clyde Canal. This was the vessel which was examined by Fulton from America and by Henry Bell from Glasgow, with the result that both of these men afterwards produced steam vessels, Fulton launching the *Clermont* on the Hudson River in 1807, and Henry Bell launching the *Comet* on the Clyde in 1811. Thus about thirty-four years elapsed from the time when Watt had made the steam engine a practical available source of energy for industrial purposes on land to the date when a serviceable steam vessel was produced.

The earliest boilers used on board ships were similar to those which were in use at the time on land—some regard, of course, being paid to the special conditions for such a situation. Weight, for instance, had to be considered, therefore boilers with as little brickwork as possible found a preference. Since space on board a vessel is valuable and limited, the boiler or boilers had to be of the minimum size that would contain the heating surface and grate area required. Then freedom from risk of fire was an important condition which had to receive careful attention, especially when we remember that the vessels in those days were entirely built of wood. The result was that boilers having internal furnaces and internal flues were naturally preferred, instead of those types with external furnaces and with external flues encased with brickwork. In some instances, however, boilers of the latter description have been known to be fitted on board vessels, but one can easily see how unsuitable they would be and unlikely to be much adopted.

The desire for the largest amount of heating surface that could be contained in the limited space available led to the introduction of what came to be known as the "Marine Flue" boiler.

A small and elementary example of this type is shown in Figs. 1 and 2, where *AA* are the furnaces, *BB* the flues, and *C* the uptake.

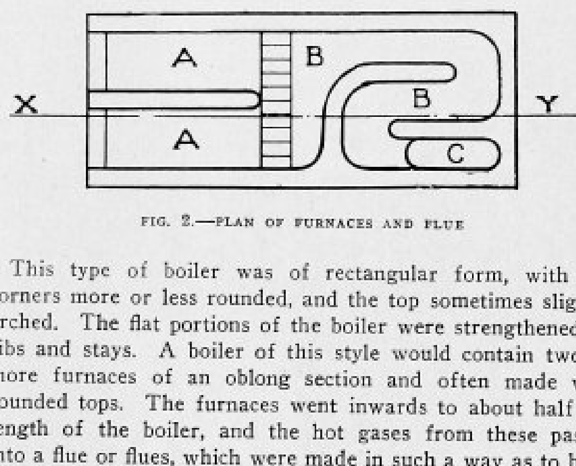


FIG. 2.—PLAN OF FURNACES AND FLUE

This type of boiler was of rectangular form, with the corners more or less rounded, and the top sometimes slightly arched. The flat portions of the boiler were strengthened by ribs and stays. A boiler of this style would contain two or more furnaces of an oblong section and often made with rounded tops. The furnaces went inwards to about half the length of the boiler, and the hot gases from these passed into a flue or flues, which were made in such a way as to bend or twist in their course towards the back end of the boiler. These flues ultimately united in an ascending flue called the "up-take."

In large boilers of this type the variety and windings of the internal flues became more complicated and more extraordinary. When the boilers were of a larger size and more heating surface was wanted in them, recourse was had to putting a tier of flues above the furnaces and the lower flues. The gases from the latter then ascended into the upper flues, and passing through them finally found their way into an up-take and thence to the chimney. Figs. 3, 4, 5 and 6 show the elevation and sections of one of these larger marine flue boilers, from which we can see the internal arrangement of flues and form some idea of the tortuous passages through which the gases had to travel.

It is of interest to note that these early boilers were almost invariably fitted with a steam chest. This formed a part of the boiler structure, and consisted of a rectangular or cylindrical box built up from the top of the shell of the boiler and open

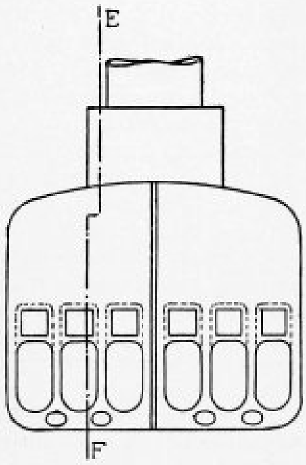


FIG. 3.—MARINE FLUE BOILER, FRONT ELEVATION

to its interior. The up-take carrying the hot gases from the flues passed through this steam chest, and the intention of the designers was that the steam generated by the boiler might in this way be dried, or even partially superheated. Another purpose served by this arrangement of placing the up-take within the boiler and steam chest was that less heat was radiated into the stokehold, and a safe lead was obtained for the hot gases leaving the boiler and entering the chimney, which was placed on the top of the up-take.

There were many ingenious arrangements of flues devised to assist in the process of drying or superheating the steam, one of the most remarkable being a spiral flue introduced by Mr. John Elder, of Messrs. Randolph, Elder & Company, Glasgow. This flue ascended through the water space and steam space, the latter being continued, in the form of a large steam chest, to a considerable height above the shell of the boiler.

On old drawings, still to be seen in the offices of some of the older engineering firms on the Clyde, one may find the

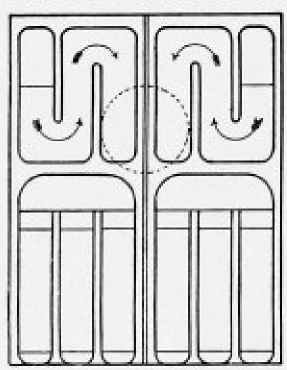


FIG. 5.—HORIZONTAL SECTION THROUGH *A B* (FIG. 4)

chimney denoted by its old Scottish name, the "lum," while the up-take is called the "lumleg."

One cannot help admiring not only the ingenuity which characterizes the numerous designs of these marine flue boilers of a past date, but also, and much more, the intricate workmanship which was involved in their construction. The plates used were of iron, Staffordshire for the shells and Lowmoor or Bowling for the crowns of the furnaces, and, while the quality might be good, we must remember that the plates were small, and, consequently, riveted and welded joints were numerous. The steam pressures carried were certainly very low, but most of the surfaces in the boilers were flat, and had to be supported by stays or by angle-bar ribs riveted on them. The flues were often worked up into most elaborate shapes, and all these operations of bending and flanging were done by hand, for there were no hydraulic tools for the purpose in those days. The riveting also was done by hand; in-

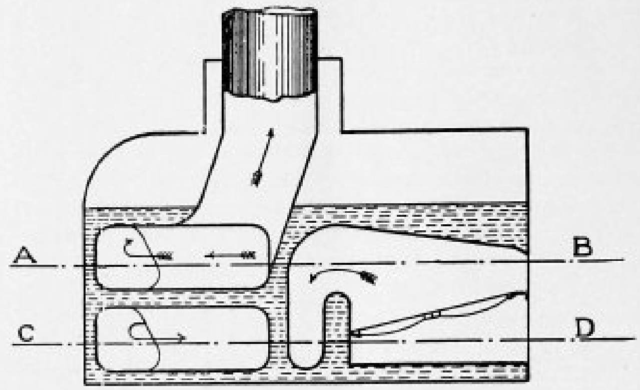


FIG. 4.—VERTICAL LONGITUDINAL SECTION THROUGH *E F* (FIG. 3)

deed, almost the only machine work that was done was the shearing of the plates and the punching of the holes—for the edges of the plates were all pared by hand and calked by the same means. To ensure tightness of the joints they were usually painted over with a solution of salammoniac, and then afterwards coated with a thin putty made of whiting and linseed oil, this being finally dried by the application of a gentle heat until it was set hard.

The boilers were often made of such a shape as would fit into the form of the vessel, the backs, or the lower corners, being cut away or rounded with that object, and they were laid down in the vessel on wooden floors covered with mastic cement.

When we come to consider the working of these boilers in service it will be at once apparent how quickly their narrow

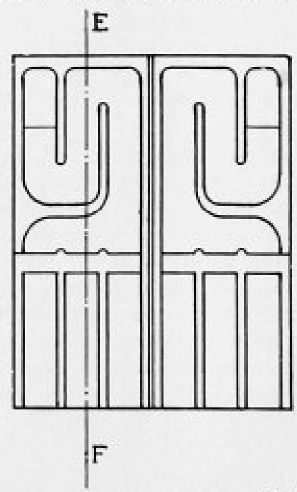


FIG. 6.—HORIZONTAL SECTION THROUGH *C D* (FIG. 4)

and twisted flues would get filled up with soot and dust, and how difficult it would be to clean them and keep them in an efficient condition.

One can imagine also the troubles that would almost be inseparable from their design and method of construction. Hence in course of time the marine flue boiler was superseded by a new design, in which the internal furnaces were retained, but the larger upper flues were replaced by tubes of small diameter. Figs. 7 and 8 illustrate this new departure. We find the furnace now terminating in a large vertical chamber at the back, which was known as the "rising flue," or the "flame chamber," or the "back up-take." This chamber rose to about three-fourths the height of the boiler, and was separated from the back end plates of the boiler by a narrow water space, or "wet-back," as it was called. From the front plate of the chamber small tubes, generally not more than 4 inches external diameter, passed towards the front of the boiler and conveyed the gases into the "front up-take." It will be observed that this was still retained within the shell of the boiler, as in the previous type; but sometimes it was placed outside the shell, and was then called a "dry up-take."

This new boiler, with small tubes instead of flues, was known as the "Marine Tubular Boiler," and embodied, for the first time in marine practice, the system of small tubes returning the gases from the back towards the front of the boiler. Doors were placed opposite the front ends of the tubes, so that access could easily be had for the purpose of cleaning and repairing the tubes. Facilities were thus provided for keeping this type of boiler in a very much better working condition than was possible with the old flue type, and the tubular boiler gradually displaced the former.

The external shape of the new boiler was still rectangular, but at a later date the top of the boiler was often made of a semi-circular form and the lower corners became well rounded.

During the period from 1828 till about 1840 steam pressures did not exceed 4 or 5 pounds per square inch. From about the latter date pressures in marine boilers began gradually to increase, and in the marine tubular boiler just described steam of 20 pounds per square inch was frequently carried, while sometimes the boilers were made for as much as 30 and 35 pounds per square inch.

This type of boiler remained in vogue for a considerable time, and, with some variation in form and design, was generally used both in merchant vessels and war vessels.

When the compound marine engine was introduced, with its consequent increase in the steam pressure to 55 or 60 pounds per square inch, a call came for some radical change in the design of the boiler. The boilers of rectangular form, having flat sides and having furnaces largely composed of flat plates, were not found suitable. A boiler was now wanted that would safely carry the greatly increased pressure, which was more than double the average working pressure hitherto carried in marine boilers. With this object Messrs. Randolph, Elder & Company, of Glasgow, who were fitting their compound engines into steamers, introduced about 1862 a boiler of new design. This, so far as its internal arrangement of return tubes was concerned, was on the lines of the former marine tubular boiler, but in order to get the necessary strength the cylindrical form was adopted, both for the shell and for the furnaces.

Thus from the desire to obtain higher steam pressures, with the advent of the compound marine engine, the Scotch marine boiler came to be evolved from the types which had preceded it.

Figs. 9 and 10 are familiar illustrations of the boiler, and from the latter of these, the longitudinal section, we see its resemblance to the immediately preceding marine tubular boiler in the arrangement of furnaces, combustion chamber and tubes. The up-take, however, does not form an integral part of the structure, but is a separate attachment to the front of the boiler, being, as the older engineers called it, a "dry up-take." The front view, Fig. 9, shows the great difference between this type of boiler and its predecessors. The circular form for the shell and furnaces marks out the design as specially well fitted to withstand the pressures that were demanded, while the same features permit of a simpler construction and greater facilities for cleaning and repairing.

The steam pressures of 50 and 60 pounds per square inch which were carried in the first of these boilers were soon increased in succeeding vessels to 90 pounds for compound engines, and from that they went at a bound to 150 and 160

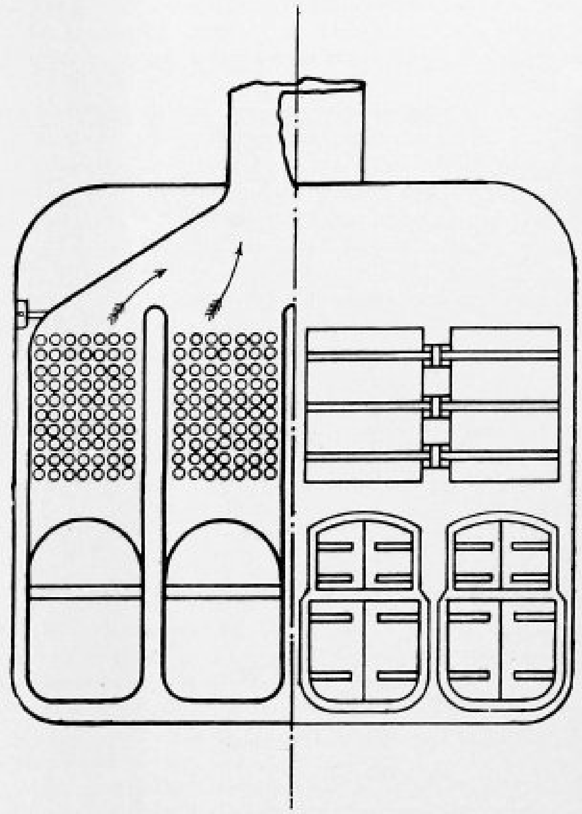


FIG. 7.—SECTION ELEVATION, FRONT VIEW

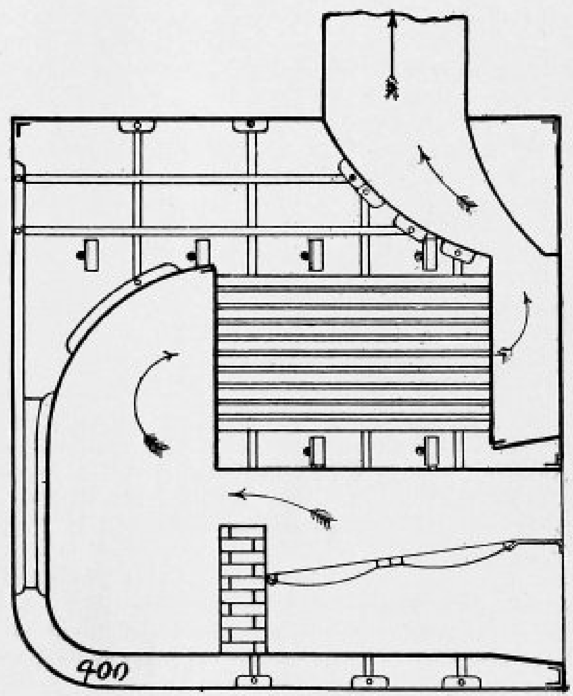


FIG. 8.—LONGITUDINAL SECTION

pounds for the triple-expansion engine. This has since been increased to 180 pounds, while for the quadruple-expansion engine and for the turbine the pressure of steam has gone up to 200 and 225 pounds per square inch, while there are instances in which boilers of this type have been made for a pressure of 250 pounds per square inch.

Notwithstanding all these advances in pressure which have taken place within the half century of the boiler's existence, there has been no change in its general design. The boiler has been taken as it stood, and simply strengthened in all its parts, a proceeding to which its form and structure naturally lent themselves.

The details of the design, however, and the methods employed in the construction have greatly changed within the same period. The introduction of mild steel made by the Siemens process put engineers in possession of a material which has been of the utmost advantage in boiler making, were it for no other reason than that plates can now be had in sizes which would have been impossible with iron. The result is that marine boilers are made with the fewest joints possible under present conditions, and we await the day when the steel maker will be able to manufacture shell plates for large boilers, rolled to the form of a shell, and without a weld or joint of any kind in them. An important change in construction is that the furnaces, instead of being invariably made of plain plates rolled into the circular form, are now generally made of one or other of the corrugated types, at any rate for boilers intended to carry the higher pressures.

Probably the greatest advance in connection with the Scotch marine boiler in recent years is the improvement that has taken place in the practice of construction. We see this

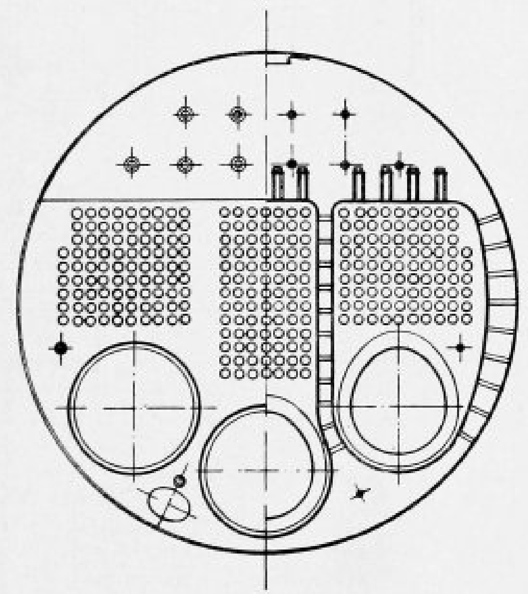


FIG. 9.—FRONT END VIEW. ELEVATION SECTION

especially in the use of exact and systematic methods, and in the introduction of fine machine tools and the large and powerful flanging, bending and riveting machines which are now to be found in all the best shops. All these have assisted in raising the manufacture of boilers to a very high level of engineering work.

More care is now being taken in the working of the boiler at sea, and better appliances are available for the supply of the feed-water and for the exclusion of air, and also of oil or other substances which would damage the boiler by setting up corrosive action.

Although the Scotch boiler has now been in use for about fifty years, it is still seemingly as popular as ever in the estimation of shipowners, and as yet it has met with no rival likely to oust it from the merchant service.

This is doubtless due to several causes which contribute to make this boiler a thoroughly reliable and suitable steam generator under many varying conditions. It is a boiler which is entirely self-contained and requires nothing external to its shell and up-take to make it ready for steam-raising.

It is very simple in construction and has scarcely any loose parts that ever require to be disconnected, while as a working apparatus it is capable of standing a very great amount of hard usage.

It is not the ideal boiler, but then the ideal boiler has not yet been realized in practice, and while the Scotch boiler is not without its defects its numerous advantages in economy of

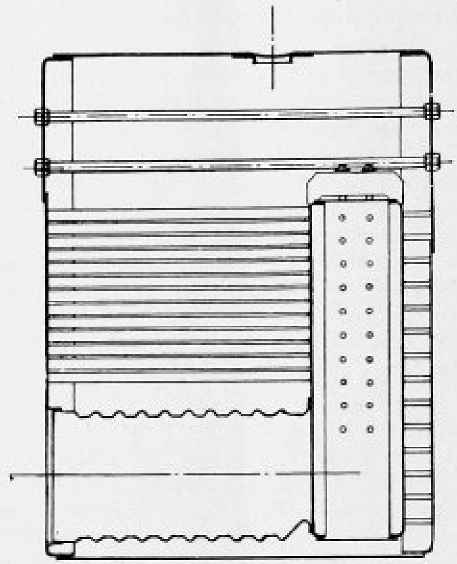


FIG. 10.—LONGITUDINAL SECTION

first cost, working and maintenance, commend it to a very large body of steam users throughout the world, who are exceedingly careful in their choice of a boiler for their particular service.—*The Engineering Review.*

Boiler Tube Failure

A boiler-tube failure occurred during a test, made some time ago, upon a Babcock & Wilcox boiler at the Redondo, Cal., power plant of the Pacific Light and Power Company. The tube was made of No. 10 gage lap-welded charcoal iron, 4 inches in diameter, and failed under a steam pressure of 185 pounds. The explosion fortunately resulted in no disaster other than placing the boiler out of service. The break is remarkable in size, being 5 feet long from tip to tip; at the central portion the tube is as flat as a board.

The boiler has a rating of 604 horsepower, and consists of 21 sections of fourteen 4-inch tubes 18 feet long. It is designed for 200 pounds working pressure, 175 pounds being carried under operating conditions. The unit is equipped with a forged-steel superheater, which gives about 100 degrees Fahrenheit at the boiler nozzle. Ordinarily, 4-inch hot-drawn seamless steel tubes are installed, the charcoal-iron sections used at the time of faiulre being primarily for the purpose of testing what they would bear in actual service.—*Power.*

The first report of the chief inspector of locomotive boilers in the United States, which covers the period subsequent to July 1, 1911, shows that there has been a diminution in the number of casualties due to boiler accidents from 12 fatalities and 260 personal injuries during the three months immediately preceding the date on which the act became effective to 6 deaths and 32 personal injuries for the like period of three months immediately following the effective date of the act.

Relative Advantages and Costs of Industrial Motor Drives

BY G. E. SANFORD

Advantages of Individual Drive

One of the advantages of individual drive over shaft drive is the saving of power. With individual drive the power is consumed only when actually needed, and none goes to waste when a machine is stopped; while with a shaft drive a large amount of power is continuously being wasted by friction in bearings and belting. As an example of this, I recently made a test to determine the power lost in a certain group drive, as a result of a complaint to the effect that the motor was not large enough to do the work satisfactorily. The motor was a 10 horsepower machine and was belted directly to a main shaft, 30 feet long, running at 300 revolutions per minute. From this were driven loose pulleys about 10 inches by 4 inches on six countershafts, as well as loose pulleys about 12 inches by 3 inches on seven drills and miscellaneous machines. A reading taken with only the main shaft and the loose pulleys running showed about half-load on the motor, this being calculated on half-load efficiency of the motor. The saving in power otherwise lost by friction of shafting is more noticeable when a plant is running a few men overtime, and long lines of shafting are running with only one or two tools in use.

With the individual drive there is a saving in labor of shifting belts from one step of a cone to another, or from a main shaft to a countershaft. A department usually possesses only one or two belt poles, and it often requires some time to find one or to wait until some other user has finished with it, and then if in getting the belt back on a mainshaft pulley it is knocked off the countershaft pulley, further delay ensues while a ladder is obtained. The labor involved in re-alining the shafting, replacing wornout bearings, etc., is also saved. This job has to be done of course when the shop is shut down, and is paid for on an overtime basis. There is also considerable time lost in looking for ladders and planking for a temporary staging, to say nothing of danger to the millwrights through working on an insecure footing. This last point may include, too, the loss of time and labor due to a burn-out in a motor driving a group of machines, as most of these motors are located on the ceilings so as to be out of the way. With a burn-out in one of these motors or trouble with a main shaft during working hours, a number of operatives will be idle an hour or more; whereas, if the trouble occurs on an individually-driven machine, the operator can usually be temporarily transferred to another machine without loss in production.

With individual drive the machines can be located to better advantage as regards floor-space and light. As an instance of economy of floor space I may cite a case at Lynn, where we formerly had all punch-presses running from shafting, and all the flywheel shafts had to be parallel with the main shaft. With this arrangement, space had to be provided for the troughs which held the uncut stock for each press. We put a motor on each of 50 or 60 punch-presses of one style, and rearranged them with the flywheel shafts at about 45 degrees angle from the aisles, so as to let the stock trough of each extend out behind the adjacent press, also putting two of these rows back to back. By doing this we succeeded in placing nine presses in a space formerly occupied by five.

A point in favor of individual drive is the facility with which the work can be taken to and from the machine by a crane. In this case the machines are wired from underneath the floor. Motors are especially well adapted to the drive of portable drilling machines and other tools used in machining pieces which are too large to be easily taken to the stationary tools.

In connection with locating with respect to light, probably everyone is familiar with the ordinary method of arranging engine lathes, end to end, and two lines back to back, the whole line being parallel to a side of the building. With this scheme, half of the men are at a disadvantage in being between their work and the light, while the other half are worse off on account of facing the light. On the other hand, if the center lines of the lathes are arranged at right angles to the side of the building, with the tail stock toward the window, the men then get the light over their right shoulders. The amount of light in a room equipped entirely with individual drives is far better than that with shaft drive, as the shafting, pulleys and belts throw considerable dirt on ceilings and walls; and this, together with the black hangers, shafting, pulleys and belts, makes a very dark combination, which gets worse with age instead of improving. I know of one building with a floor space of approximately 90 feet by 190 feet, which has on the third floor a large number of screw machines, these having from two to four belts each, from the countershaft to the machine, depending on make and style. The height of this building relatively to that of the surrounding buildings is such that no shadows are cast on the windows of the room from 8 A. M. until nearly sunset; but in spite of this it is necessary to keep incandescent lamps burning all day at the machines in the middle of the room.

In a modern shop, if the management is at all progressive, it is necessary to provide for additions and re-locations of machinery from time to time. With motor-driven tools it is a simple matter to remove the wires between the mains and the machine; whereas with the shaft outfit it means that, to remove the pulley belonging to that particular countershaft, it may be necessary to uncouple and take down part of the main shafting (if the pulley is solid, as most of the old ones are); and it is then a lengthy business to strip off anywhere from one to a dozen other pulleys in order to get the one which is required, put back the others, set up the shafting and re-aline each pulley moved. The whole performance has to be gone through again when putting the pulley up in the new location.

With individual drive on a machine, the efficiency is greater than with the shaft drive, on account of the motor being nearer the work. This difference in efficiency is most noticeable in a comparison of adjustable speed machines, with direct current motor having a number of points with slight variations in speed between points, and in other cases where there are 4 or 5 steps on the machine cone. With the individual drive the operator is able to keep the speed at the maximum by a touch of the controller, for both tool and material, when working on stock of varying diameters, as, for instance, in facing a disk.

On punch-presses, power shears, etc., the number of accidents to operators is noticeably less with individual drive, as the general arrangement with shafting drives consists of a belt from a pulley on the main shaft to the machine flywheel; a touch of the treadle will cause a complete cycle on the machine, with possibly disastrous results to a man engaged in setting a die or adjusting a shear blade. Instances have been known of men being seriously injured by accidentally hitting the treadle. With individual drive the motor may readily be shut down before any adjustments are made.

RELATIVE COSTS OF GROUP AND INDIVIDUAL DRIVE

If a manufacturer is considering a new building, new tools, etc., the methods of driving the tools will be a very important question. Some will go into the subject as far as to find that the initial cost of the individual drive is much in excess of that of the group drive, and decide immediately in favor of the latter without making a proper study of the question of maintenance and other points. The following figures are based on the requirements of a small machine shop:

Original cost of group drive, $5,840.00.

Original cost of individual drive, $7,165.00.

Excess cost of individual drive, $1,325.00.

There are certain losses incidental to the group drive which do not occur in the individual drive. These losses as estimated for the above group drive per annum would be about $555.00. From this it is evident that in about 2½ years the increased cost of the individual drive would be wiped out.

The friction loss would probably be increased, however, if power was purchased from a public service corporation, the increase being dependent on local conditions as regards rates, etc. Furthermore, if there were no heavy shafting to suspend from the roof trusses, there would be a saving of possibly 5 percent in the cost of the building.

SELECTION OF MOTOR SIZE FOR REQUIRED SERVICE

In connection with the selection of motors to drive tools where the power required is not known, it is customary to set up a temporary motor large enough to carry the maximum load on the machine, and make careful tests to determine the average and maximum loads. It is usual then to select a motor based on the average conditions, provided that the maximum is not so great as to stop the motor or slow it down to such an extent that it cannot regain normal speed before the maximum is on again. This is based on an overload rating of six hours at 25 percent, and momentary at 50 percent overload. In cases where the load varies rapidly, as, for instance, the reverse of a planer, it is usual to add a flywheel to the main driven shaft to help out over the peak load.

It appears from tests which have been made that machine tool makers in many cases use motors which are altogether too large. The following data were obtained on a 48-inch planer fitted with a 20 horsepower motor: Cutting stroke, 4 tools each ⅛-inch feed by ⅛-inch deep, 2 in scale and 2 in second cut, cast steel at 37 feet per minute, 9.8 horsepower; reversing bed to run back 25 horsepower, approximately; running back 10 horsepower; reversing to cut 25 horsepower, approximately. This machine was fitted up by the maker, but if a 15 horsepower motor had been used I do not think it would have given any trouble.

A test on a 24-inch planer showed the following: Cutting stroke, 3 horsepower; reversing bed, 8 horsepower; running back, 6 horsepower. We fitted this planer and three or four others like it with 3 horsepower induction motors about two years ago. All but one have given no trouble; that one, however, is set for a very short stroke, only two or three inches; and after we melted the solder out of several rotors, we changed to a 5 horsepower. We are having a 3 horsepower rotor made with conductors and end rings cast in one solid piece, and intend to put a 3 horsepower motor back when we get this.

Another palpable case, where an unnecessarily large motor is installed, recently came under my notice. In this instance a 26-inch disk grinder was driven by a 20 horsepower motor with the shaft extended on each end, carrying two steel disks about ¾ inch thick with emery sheets pasted on them. A test was made with two men, each holding a piece of cast iron with a bearing surface of about 24 square inches. Both men were above the average in strength and had pieces of stock on which they could get a good grip. They were instructed to stop the motor if they could. The maximum horsepower noted was 6.3.

Another interesting grinder test was made on a machine with wheel 24 inches by 3½ inches. This was equipped by the maker with a 5 horsepower shunt motor, and connected to the wheel with a silent chain. Under these conditions it was apparently considered necessary to have a fairly large motor in order to overcome the inertia in starting the wheel, since, of course, there was no momentary belt slip to aid the motor in getting up to speed. A test with large planer tool under ordinary conditions took 2.4 horsepower. A test with a man holding the end of a ¾-inch by 2-inch machine-steel bar against the stone with all the pressure he could exert took 4 horsepower. This motor was removed and replaced with a 2 horsepower induction motor with ordinary belt, and this has been running for nearly four years. We find that most small engine lathes are fitted about right, the only ones undermotored which I recall being the 12-inch and 14-inch of one certain make. These two sizes have given us considerable maintenance trouble, due to armature burn-outs from overload.

A certain tool company could easily use smaller motors on any of their lathes under 24 inches. For example, they use a 3 horsepower motor on a 16-inch machine. We had a case some time ago where a lathe of this size was speeded too high for the class of work required of it, so we replaced the 3 horsepower motor with a 2 horsepower slow-speed motor. The department foreman was somewhat afraid of this reduction in power, as he did not want to be responsible for burning out the motor; so we arranged a maximum load test, where I was to watch the instruments and he would operate the lathe, each of us to take the responsibility for our own part of the outfit. The first cut in cast steel 3/32-inch chip, 0.01-inch feed, 47 feet per minute, took 1 horsepower. This shook some tools off the lathe bed. With the second cut the depth was doubled, and this took 1.6 horsepower. The test was stopped while some of the screws in the machine, which were loosened due to jarring, were fixed up. The stock was changed and the test continued, using machine steel. The machine then jarred excessively on the following tests:

¼-in. chip 0.022 in. feed 72 ft. per min.... 3.1 horsepower

¼-in. chip 0.044 in. feed 40 ft. per min.... 3.8 horsepower

We then tried doubling the feed again, and after two or three revolutions of the stock broke the lathe. These tests showed that a 2 horsepower motor would do any work that the lathe could carry. We have since changed over more of these, putting on 1½ horsepower motors.

LOCATION OF MOTOR RELATIVE TO MACHINE

With regard to attaching the motors to machines, many tool manufacturers are building their machines with the motor drive included as a part of the machine. With old machines, however, it is an entirely different proposition. The motors should be located so that as far as possible they will not add to the floor space occupied by the machines, while they should also be so arranged that the shop attendant can easily get at them to clean or make repairs. They should be out of the way of the operators, but the controller or switch should be within easy reach. In some cases, *e. g.*, a band-saw, it is practically impossible for a man to reach the main switch from the operating position, so we have located emergency switches under a corner of the saw table which can be used to stop the motor. Large machines may be equipped with circuit-breakers having a no-voltage release, and small switches connected to this coil may be located at operating points.

The cost of installation should be kept down to a minimum, but should not be done so cheaply as to prejudice a visitor against changing his machines. Cast brackets should be used in preference to forgings, as a few well-designed patterns can often be used on several different machines by trimming fitting strips and filling the crevices with soft metal. Attention should be given to the appearance of the drive, as a set of brackets with square edges and corners looks decidedly out of place when attached to a machine the general lines of which are well-rounded. It is surprising how much improvement can be made in the looks of a casting if the patternmaker spends a little extra time in rounding the corners and edges of the pattern.

In laying out a drive for an old machine, it is necessary to make very careful measurements of the machine, and to make an outline sketch to scale of that part of the machine to which the motor will be attached, leaving out all parts not actually required. With an outline sketch of the motor it is then an easy matter to select the relative location. We have a number of cardboard motor outlines which are tacked over outline drawing of the machine, and which often save time in determining the exact location for the motor. Most of these layouts are made on a scale of 3 inches to 1 foot, but we also use 1½ inch to 1 foot on some of the simpler jobs, and half scale on some of the complicated ones. We have on rare occasions made a full-scale layout on the floor in order to get certain measurements or locate just where a belt will go.—*General Electric Review.*

A Boiler Shop Order System

BY JOHN ROSS

A shop order system to be a success should live up to its name strictly. It should be the means of obtaining order in handling the work, of keeping track of the various parts in process, and of compiling records of work and costs. Guesswork and indecision in any of these branches surely indicate either an inadequate system of handling orders or a laxity in enforcing its provisions.

The large boiler shops handling an annual output of business amounting perhaps to millions of dollars have every operation well standardized. Their methods of handling orders through the various processes, while perhaps far from perfect, are in the main efficient, and necessarily so, as confusion among so many units would inevitably cripple the production. But what of the countless little boiler shops scattered all over the country, shops that usually turn out just as good boilers as the big fellows, but in far smaller quantities? Unfortunately, as much cannot always be said for their management and methods as for the quality of their product. And right here is a big reason why the small shop cannot usually sell profitably at a lower price than its big competitor. The latter's more efficient shop organization reduces shop costs enough to offset the greater selling and general overhead expense incident to a large establishment. If the small rival were as well organized its total costs would, in nine cases out of ten, be lower, allowing the same percentage of profit.

Why, then, doesn't the small shop organize itself properly on the plan of its big neighbor? Why does not every manager take advantage of this opportunity to compete with the million-dollar plant? For two principal reasons. First, because the need is not usually an apparent one. Second, because if the necessity for such a course of action is seen and appreciated, the proper way to accomplish the desired end does not suggest itself. Perhaps the small shop's manager has come to a realizing sense of his own plant's inefficiency and goes to work to find out what sort of organization is behind the perfect discipline and orderly procedure of the big Blank Works. He finds out—and gasps! He discovers a battery of clerks and assistants—most of whom are engaged in filling out, dispatching and making entries from what is apparently a whole multitude of cards, forms, sheets and similar paraphernalia. He listens, watches and shakes his head! System is all right for the Blank people—they can afford it—but his shop, with its one building and its hundred employees, would be swamped, he thinks. And so it would with Blank's system, and right then he makes the usual mistake. He fails to see that the smaller and simpler a business is the simpler and easier its systematizing.

Grant that an order system may be desired for a small boiler shop that will not load the men and the management with a mass of red tape and eat up whatever profits it might create by the costs incident to its application. In what should such a system consist? Perhaps a concrete example will prove most illuminating. Assume a shop employing 100 men, and assume again that its business is to build horizontal return tubular boilers. The work would be divided between stock boilers and boilers built to order. In such a business the stock boilers would probably predominate, as the design of this class has become fairly well standardized. For quick deliveries it is good policy to keep on hand a certain number of finished units of the sizes usually in demand.

First of all, the work is classified by departments, and each department numbered. Probably in one end of the shop, in a small enclosure, works the blacksmith with a couple of helpers. They form a department. The boiler-making proper is done by the boiler department. The machine department, sheet iron department, shipping, receiving and foundry (if there is one) each represent a separate little organization. For convenience it is usual to dispense with names and substitute numbers—as, for example, Department No. 1, the boiler shop; Department No. 2, machine shop, and so on. All orders carry numbers also, divided into three classes: production, standing and stock, with perhaps one other and little-used class—namely, general orders.

Every order, of whatever class, carries on its face its number at the top—as, for example, Production Order No. 5,643, or Standing Order No. 301—and also the number of the department to which it is directed and to whose work it relates. It states exactly and concisely what that department should do to accomplish the desired ends. It forms the superintendent's or manager's instructions concerning the work in hand.

The general order is sent from the manager's office to every department, and always relates, not to individual work but to matters of general application in the shop. For example, the management's decision to change the daily hours of work of the establishment would be communicated in a general order. Furthermore, the general order is not temporary in its authority, but holds good until modified or rescinded by another general order of later date. It is a not unusual custom to post general orders in a conspicuous place in each department.

The standing order is likewise permanent. It is used to designate work of a general nature which cannot be charged to any of the jobs going through the shop. For example, the shop windows must be washed periodically. To what should the men's time, the washing soap and waste be charged? A standing order covering building up-keep or some similar classification will cover such cases. In making out the standing order list care has to be exercised to cover all classes of expense items so that the costs can be determined accurately without classifying too minutely. In order to make the standing order numbers easy to remember and so avoid the bother of referring to a list, some such arrangement as this can be adopted. The numbers representing the expense orders of a department are grouped under a first figure corresponding to the department's number. Thus the standing orders for Department 2 would be Nos. 201, 202, 203, etc., and Department 8 would have Nos. 801, 802, 803, etc. Also the last figures in the standing order numbers designate the kind of expense, and are the same in each department. Suppose, for example, that 201 was the order number for the foreman's time in Department No. 2, then 701 would be the foreman's time in Department No. 7. Besides the standing orders of a strictly departmental nature, as those mentioned above, there are orders covering general work of the shop, as crane service, cleaning up, etc.

Stock orders and production orders are both concerned with work to be done on specific boilers. The difference is that, in the case of stock orders, the boilers made have not been sold when the order for building them goes through, whereas production orders are for boilers specifically ordered by buyers through the company's selling department and represent "made-to-order" work. Production orders are usually given serial numbers running through the year, or sometimes extending over several years. Stock orders may be given serial numbers in the same way or they may be divided into several series, each series denoting one size and type of boiler. Thus, suppose a stock order is issued to build ten 72-inch boilers with tubes 18 feet long. This might be stock order No. 7,201, and the next order for that size and type be 7,202, and so on.

To illustrate the handling of stock and production orders through the shop, assume that the works office has issued production order No. 4,321 to make four 60-inch by 16-foot boilers for a customer. A copy of the order containing all the information at the disposal of the office goes to the draughting room. Here departmental orders are made out in the form of blue printed or manifolded lists showing every part going into the construction of these boilers and indicating in columns the number of each part required, the drawing number, pattern number, material, size and routing of the piece. There is also a column for check marks at the extreme right. These lists are then sent to the works office, where they are attached to departmental notices signed by the superintendent and carrying a date on which the work should be completed.

Each department doing work on this order (as indicated by the routing list) is then sent its order, as are also the shipping clerk and storekeeper. The routing column on the list sheet has after each item the departments, indicated by numbers, that work on that particular piece, and these numbers are arranged in whatever order the different departments do their work. As each piece is finished, and either assembled or turned over to the next department, the foreman checks the item on his list. At the end of the work the foreman writes his name and the date on the order and returns it to the superintendent, indicating the completion of his part of the work. These lists, when assembled and filed in the office, form a complete record of the work done on that order.

All raw material needed is requisitioned by the various departments and checked by the storekeeper with his complete list. The requisitions after being filled are turned over to the cost clerk for extension and entry against the order, and also for making a new balance of that particular material on the proper stock card. Time cards are treated in the same manner, being extended for total cost against the order and checked against the payroll. All time must be charged on the cards by specific order numbers, with a statement in condensed form of the kind of work done. There should be one card for each order worked on by each man. Thus, if the same man worked on three different orders during one day, he would turn in three different cards, showing just how long he worked on each and what he did. In the same way material requisitions should each carry but one order number. This arrangement makes it possible to group all labor and material on each order, thus facilitating the cost determination.

An order system of the general type outlined can be installed and operated in a small shop successfully. In reading over the list of forms and methods it may appear a formidable matter, but in actual practice such a system is simplicity itself. As a matter of fact, it will be found that the time (and therefore money) consumed in following such a scheme is far less than where no organization of the work is attempted. In the latter case, valuable time is too often wasted because some department has not completed some essential part. That department may have been overlooked in the stress of "getting out the work" and no definite instructions issued. Without organization the thousand-and-one details connected with the progress of work through the shop fall upon the superintendent and foremen, with consequent loss of discipline and efficiency. Changes in construction or design are not always known in time to prevent costly errors, and the work of each department is not properly related to the work of every other. Under the order system the work is definitely laid out and every man has full instructions. The exact state of the work can be ascertained at any time, and responsibility is set squarely on the proper individual. For example, suppose, after shipment, it develops that a grate rest is too short. Whose fault was it? A glance at the list of parts on this order identifies the grate rest. Comparison with the drawing shows that the proper rest was specified. Then the pattern number proves to be the correct one. At once the field narrows down to the foundry foreman and the shipping clerk. The former got out the wrong pattern, and the latter shipped the rest without verifying the number moulded on it by his list. (Incidentally, all patterns should have their numbers nailed on in raised letters, so that the number will be easily read on the resultant casting.) With any other blunder the route to the seat of the trouble is equally simple. Written orders bear testimony indefinitely. Oral orders are easily and often unintentionally forgotten or misconstrued. The man works best, whatever his position, who realizes that the responsibility for his work rests on himself.

An order system works two ways. In the shop, by eliminating delays and confusion, it increases production and lowers costs; in the office, by furnishing exact data, it makes possible the compilation of correct costs, for every item of labor, material and shop expense is accounted for and classified. Quotations are no longer 10 percent guesswork when the real costs are available. Hence the manager is able to offer prices upon which he can be sure of his profit.

It is perhaps superfluous to add that where an order system is installed it must be followed exactly. It is useless to build a fine engine and leave out the crank pin. At first errors and disputes will arise, but once it is understood that the provisions of the system must be observed, and that whoever is delegated to enforce them has full authority, lapses will become less frequent. As soon as all hands are used to working systematically and results begin to appear, the shop will go along steadily and with far less friction than under the old régime.

When three thicknesses of plate are to be riveted, as at the fire-door ring in a vertical boiler, there are some differences of opinion as to the size of rivet that should be used. The same size of rivet that would be used in a lap joint would probably be strong enough in the three-ply joint, but more care must be used to make a good steam-tight joint because there is a longer length of rivet to upset and fill the hole.

Every-Day Geometry Stunts Exemplified for Boiler Makers

BY JAMES F. HOBART, M. E.

"Geometry!" says the boiler maker. "What the deuce do I want with geometry? I've got all I can do driving rivets and calking seams without monkeying with geometry. What good is it to me, anyway?"

But for all that the boiler maker does use geometry. He uses it every day and doesn't know it. If I should tell him to eat chloride of sodium on his meat and take a drink of hydric oxide right afterward and he would feel fine, I might get chased out of the shop; but for all of that the boiler maker is willing to eat salt on his meat and drink water afterward.

Every time the boiler maker cuts a sheet 3.1416 times the diameter, to roll up a shell, he uses geometry; and every time he adds three times the thickness of the stock to make the shell come out large enough, then he uses some more geometry. Each and every inch in diameter requires 3.1416 inches of shell; and in adding three times the thickness to make up for the shrinkage during bending, the boiler maker only uses a rule-of-thumb method of adding 3.1416 times the thickness of sheet.

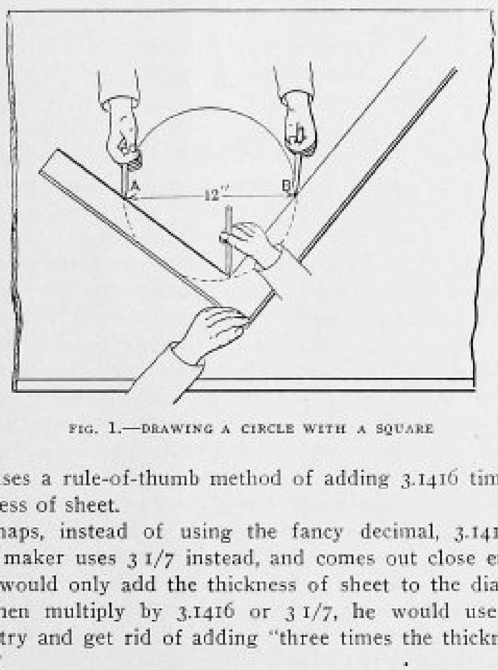


FIG. 1.—DRAWING A CIRCLE WITH A SQUARE

Perhaps, instead of using the fancy decimal, 3.1416, the boiler maker uses 3 1/7 instead, and comes out close enough. If he would only add the thickness of sheet to the diameter, and then multiply by 3.1416 or 3 1/7, he would use more geometry and get rid of adding "three times the thickness of sheet."

Mr. Boiler Maker, did you ever happen to think that geometry is nothing but a high-class tool for a high-class man to use? Can't you do more and better work, and do it easier, with air tools than you can with hand-hammers and chisels? Then why not make use of a little geometry now and then instead of some ancient "by guess and by G——" method? Geometry is just a good tool for a good man. The poor man can't use it, therefore go to it and use the best tools and methods you can get hold of, and therefore qualify for the best jobs and the best pay that is going.

The two little geometry stunts illustrated by the following engravings will be found very useful in the boiler shop, and if you were not told, Mr. Boiler Maker, I'll bet you would never know they belonged to the geometry tribe!

Sometimes, Mr. Boiler Maker, you may have gone out on a job and forgotten your square, or perhaps you have forgotten to bring along a pair of compasses. First thing you know you want to lay out a 12-inch hole and you have to drive two nails in a bit of stick and strike the circle with that rig. Fig. 1 shows how the stunt can be done without any compasses or nails in a stick. The square and a scratch is all that is needed to do the trick.

Fig. 1 shows this bit of shop geometry. Just drive the center punch into the sheet at *A* and *B*, just 12 inches apart; then have the helper hold two scribers, scratch awls, two pointed wires or two wire nails, as shown by the engraving. Next, place the inside of the steel square against the points in the holes, place a scriber or a pencil in the angle of the square and move the square with the left hand, holding the marker with the right, as shown by Fig. 1. It is best to mark both ways from the center, the position in which the square is shown by the engraving; the square will keep against the points much better when it is pushed either way than when the attempt is made to mark right around from one center point to the other. After marking a half circle on one side of the points place the square on the other side and mark that half-circle also.

The reason why the corner of a square, when moved as above, will travel in a true circle depends upon a proposition in geometry that "Any angle in a semi-circle is a right angle." This truth is shown by Fig. 2. Just try it for yourself on a bit of plate. Put one leg of the dividers at *G*, the other at *C*, and draw a half-circle right around to *D*. Next, put the straight edge on *C*, and draw a line to anywhere in the circumference of the circle, say to *E*. Draw another line from *E* to *D*, and the two lines will be exactly square with each other at *E*.

Try it again, drawing lines from *C* and *D* to *F* this time, as shown by the dotted lines. The angle at *F* will be 90 degrees, or "square," every time. This is a good way to test out the shop square to see if it is "out" or "in." Draw the lines carefully, and no matter to what part of the semi-circle they are drawn the angle next to the circumference will always be 90 degrees, or a right angle. So much for geometry. Notice the square in Fig. 1. When it travels from one end of the half circumference to the other the inside edges of blade and tongue are the two lines corresponding to those shown by Fig. 2 at *C E* and *E D* or *C F* and *F D*.

It has been shown (by Fig. 1) how a circle may be drawn with a square, also (by Fig. 2) how a square may be drawn by a circle, but the following engravings show how to apply this bit of geometry so as to make a mighty handy tool for the boiler maker—a tool which, I am sure, cannot be found in any shop in the United States.

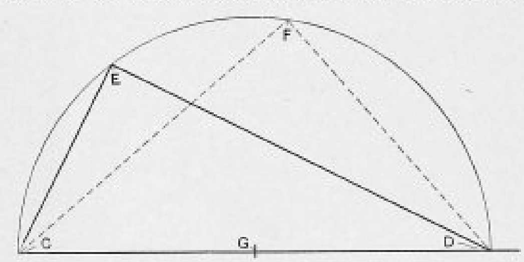


FIG. 2.—DRAWING A SQUARE WITH A CIRCLE

To make a compass which will draw a square, get a bit of flat steel of any convenient size or length. It may be made 6 inches long for small work or 6 feet long for large work. Pick out size and length to suit, then drill two holes as shown at *A* and *B*. These holes should be drilled and reamed, fair and square. The ends of the piece should be rounded as shown. Next procure another piece of the same sized bar, but nearly twice as long as the first piece. Drill and ream a hole of the same size at *C*.

Fit a rivet or a bolt very carefully to hole *C*; place hole *B* also upon the rivet and fasten the two pieces together as

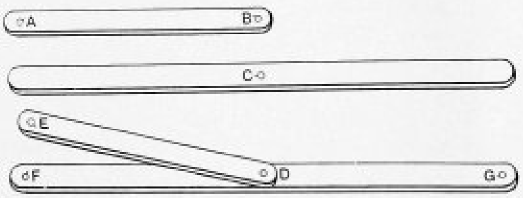


FIG. 3.—COMPASS FOR DRAWING A SQUARE

shown at *D*, fitting the bolt or rivet so snugly that the short piece can be turned easily, yet without any lost motion whatever. When the rivet or bolt at *D* has been well fitted, swing hole *E* around fair upon the longer piece and drill hole *F* right through hole *E*. Then swing *E* around to the other end of the longer piece and drill hole *G*.

Some sharp points should be fitted to the three holes *E*, *F* and *G*, and it will be well to make a good job of it and fit in some center punches, which may be removed for grinding when necessary, and replaced in the holes without changing the length between marks made by the center punches.

FIG. 4

Fig. 4 shows one method of making center punches for this tool. The punches, of which three will be required, are turned up in a lathe, shouldered to fit snugly in the holes in compass beam, and threaded to receive the nuts which hold the punches in place. A threadless shank is left above the nut, and the hammer is used upon the top of the shank when a mark is to be made in a sheet by one of these punches.

Care should be taken to make all three of the punches of the same diameter in the large part below the bar or rod. Of

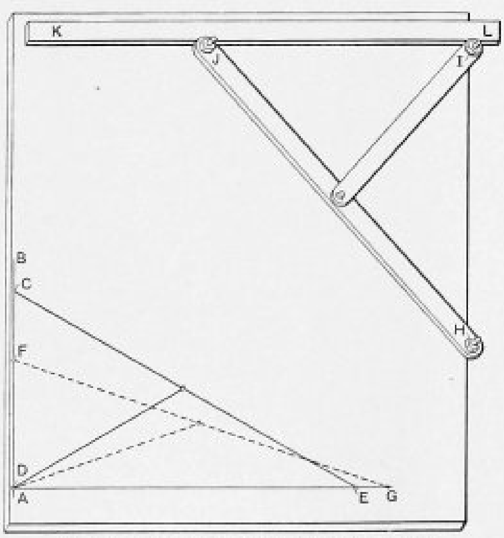


FIG. 5.—USING A SQUARE DRAWING COMPASS

course, all the smaller portions must also be of the same size, so as to fit the reamed holes in the bars.

In using the instrument, suppose it be desired to square across a sheet from point *D* on line *A B* (Fig. 5). Place the end of the short arm at *D*, the center punch being driven into the sheet same as any center punch would be used. Next place the center punch in one end of the long beam, anywhere upon line *A B*. Suppose the punch happens to strike at *C*, Fig. 5. Drive the punch into the sheet to make the instrument stay in place; then, with both the center punches fair in their holes, strike the other punch with a hammer, making a center mark at *E*.

It will be found that a line drawn from *E* to *D* will be exactly square with line *A B*. And it will be found that, no matter where in line *A B* center punch *C* may be placed, the long arm will always lie over line *E D*. The instrument being moved to the position shown in Fig. 5, by the dotted lines, one center is placed at *F* instead of at *C*. In this case the other end of the instrument travels right along in line *E D*, and is found at *G*. Therefore, no matter where, in line *A B* point *C* may be placed, point *E* will always fall in a line square with (perpendicular to) line *A B*.

The method of using the tool as shown is for locating three points in a right angle upon a sheet. When there is a straight side which it is desired to work from the tool may be placed as shown at top of Fig. 5. Two of the center punches, say *H* and *I*, are placed outside of and against the edge of the sheet as shown, then a thin straight-edge is placed against center punches *I* and *J*. The straight-edge *K L* is now square with the edge of the sheet, no matter where points *H* and *I* may have been placed. It is for this purpose that the center punches are required to be all of the same size.

Layout of a Funnel Hood When Raked to the Same Degree as the Funnel.

BY I. J. HADDON

The pattern for this is *not* a frustum of a right cone cut at an angle, as some would imagine, but the frustum of a cone that has an elliptical base. In the small figure I have shown how the plan and elevation of this would look. I have also put the funnel and hood at a greater rake than is usually required, but that is to show more clearly that it has an elliptical base, and is a frustum of an elliptical based cone, as the less rake there is the nearer the hood becomes a frustum of a right cone.

I have drawn the whole of the funnel showing the whole of the hood, but in practice this is not necessary, only one-half being required to obtain all the particulars necessary for the layout, as I will explain.

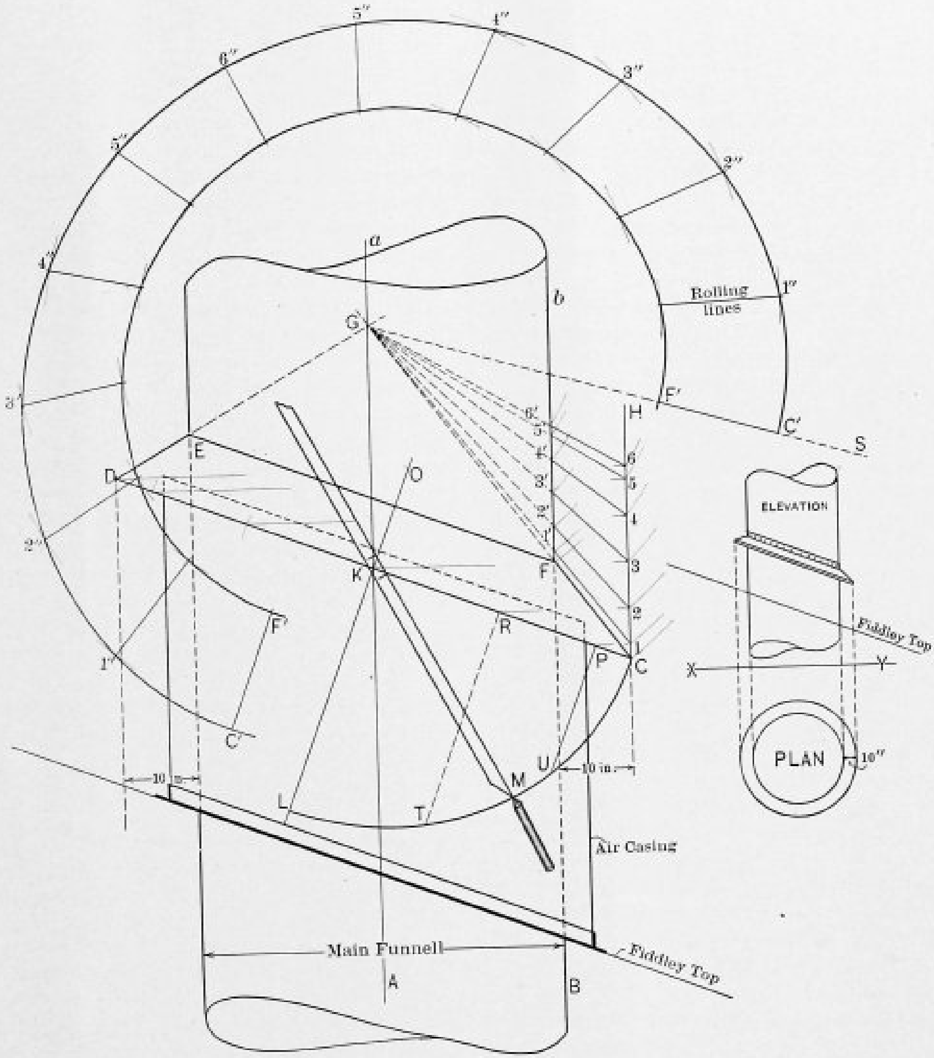
Draw the lines *A a* and *B b*, representing the center line of the funnel and the outside of the funnel, respectively; draw the parallel lines *C D* and *E F* at the rake required, and distance apart as required; draw the line *C H* parallel to *B b* and the required distance away from *B b* as shown, say 10 inches, which is quite common.

Produce *C F* until it cuts the center line *A a* in *G*; draw *K* 3 perpendicular to *A a*; draw *K L* perpendicular to *D C*, producing the line slightly beyond *K* as shown at *O*. Make *K L* equal to *K* 3, then *K L* will be half the minor axis and *K C* half the major axis of the elliptical base *D C*.

Now mark out the quarter ellipse as shown; this may be done as follows, which is perfectly accurate and a very quick method: Procure a straight-edged piece of batten, and mark on it from the end *M*, the lengths *K L* and *K C*; now lay it on the line *K C*, and move the point *M* around towards *L*; but at the same time one of the marks on the batten must travel on the line *K L* towards *O*, while the other mark travels towards *K*, and by keeping a scriber at *M* the quarter ellipse may be drawn. It will be easily seen that the whole of the ellipse may have been drawn if necessary with this batten.

This is a good method of marking out manholes, as you may use your 2-foot rule instead of a batten.

Divide the quarter ellipse into any number of equal parts, measuring along the curve as at *U T*, and project the points obtained up to the line *K C*, as shown in *P R;* draw *P* 1 and *R* 2 parallel to *K* 3, cutting the line *C H* in 1, 2. Make 3 4, 4 5 and 5 6 equal to 3 2, 2 1 and 1*C*, respectively, or divide where they intersect, which will give the bottom curve of the developed hood. Now draw lines from 1", 2", 3", etc., towards *G*, thus cutting the inner arcs as shown, when a fair curve may be drawn through their intersections as was done for the bottom. These lines will be rolling lines.



LAYOUT OF FUNNEL HOOD

K D off similar to *K C*, and from the points obtained project onto the line *H C*, as shown.

Now from 1, 2, 3, 4, 5 and 6 draw lines to the point *G*, cutting the line *B b* at 1', 2', 3', 4', 5' and 6'.

Development

Draw the line *G S* at any convenient position, and with *G* as a center and radius *G C* draw the arc cutting the line *G S* in *C'*. Now with *G* as a center and radii *G* 1, *G* 2, *G* 3, etc., draw arcs as shown at 1", 2", 3", etc. Proceed in a similar manner to obtain the arcs for the inner curve of the layout; that is, with *G* as a center and radii *G* 1', *G* 2', *G* 3', etc., draw arcs as shown. Now obtain a thin lath or batten and bend it around the quarter ellipse, and mark on it the points *C, U, T, L*, which, as I said before, are equidistant. Now this must be done four times to equal the distance all round the base of the hood, but, of course, you may do one-half at a time if desired. Having done so much, place the point *C* on the batten to the point *C'* of the development, and bend the batten around so that the points *U, T, L*, etc., lie on their respective arcs, as 1", 2", 3", etc. Then draw a fair curve through

Now the necessary allowance should be made for flanging at the top for connecting to the funnel, as shown in the small sketch; also, the lines *C' F'* represent butts; if lap joints are required the lines *C' F'* would represent the center of rivet holes.

When flanging the top to fit the funnel the bevels may be taken, such as the bevel 3, 3', *b*, and applied along the rolling line 3", and so on. If molding is required around the bottom of the hood, which is sometimes the case, it should be bent on edge to the shape of the developed plate before bending on its flat to fit the hood.

As these hoods are generally made up of six plates, of course it is only necessary to lay out one-half of the development, or for three plates, and make the other three plates to pair with them.

The Parker Boiler Company, Pennsylvania Building, Fifteenth and Chestnut streets, Philadelphia, has bought a site of three acres at Lafayette Station, Pa., and has started to build a modern boiler manufacturing plant. Room is available for shops 900 feet long, averaging 130 feet wide.

Process of Autogenous Welding and Cutting of Metals*

BY HENRY CAVE †

Autogenous welding is the uniting of metals into one solid mass by fusion without the intervention of a different metal. You will note that the pronunciation of the word is aw-todg-e-nus, not auto-genous as nine-tenths of the people seem to wish to call it. The definition of the word is auto, self; and geneous, generated; self-generated or self-produced; meaning that the weld is produced by merely liquefying the parts and allowing them to run together.

There are several types of autogenous welding, the one which is to be considered in this paper being carried out by means of the oxy-acetylene flame—that is, acetylene gas burned with pure oxygen, which gives a flame temperature of 6,300 degrees. The foundryman's "burn" is really not autogenous welding; he uses a large mass of molten metal poured over the piece to bring it to a liquid state; and when this point is reached, the pouring stops and the metal remaining in the mold forms part of the piece to be welded. There is a type of electric welding called arc welding, which is autogenous, the electric arc being used to fuse the parts together; the ordinary form of electric welding is not autogenous, as pressure is required to force the parts together. The ordinary blacksmith's form of welding is not autogenous, as the parts are merely brought to a plastic condition and hammered together. Brazing and soldering are not autogenous, as a different material of a lower fusibility than the parts to be welded is used to run in between the parts on which the work is being carried out. Thermit welding might be termed partly autogenous, as the metal used might be of the same nature as the parts being welded, and it is merely used to raise the temperature to the melting point, similar to the foundryman's "burn."

The first inception of the oxy-acetylene process was in 1895 in France. It seems to be the case that the majority of the developments and inventions that originate in the laboratory and scientific end come from abroad, the great inventions of this country apparently being developed from a practical end and the theory worked out afterward.

The oxy-acetylene process was first thought of by Le Chetalier, the well-known scientist, who figured out that by burning acetylene with pure oxygen a temperature of 6,300 degrees could be obtained. You will note that this was immediately after the commercial development of calcium carbide to produce acetylene at a reasonable price. It was not, however, until 1901 that the process could be used, owing to the practical considerations of making a satisfactory torch. You can realize the difficulty of uniting oxygen and acetylene in a torch, and keeping the flame burning on the outside, they having the tendency to ignite at the point where they first come together. This at first was prevented by the use of hydrocarbon gas along with the acetylene. In 1903, however, developments had been worked out which did away with this necessity and a really practical torch was placed on the market in France. It was not until 1906, however, that an equipment was brought into this country for actual manufacturing purposes, though a torch came into this country in 1904 and was used experimentally; from that time, however, there has been rapid development in both the equipment, the uses for the process and the method of carrying out the work. At the present time, I believe the equipment to be as complete as it is possible to make it, the developments of the future being merely in methods of operating, and also in the scope of the work.

A good idea of the temperature, 6,300 degrees, is obtained from the fact that if a thermometer had a scale eight inches long between freezing and boiling, it would require to be about twenty-one feet long to measure the temperature of this flame on the same scale; the 6,300 degrees is, of course, Fahrenheit. The method of using this flame is to merely melt the parts together, which would be termed re-casting locally. Where a part has considerable thickness, it is necessary to remove the metal so as to form a groove; the flame is then applied to the feather edge at the bottom, and this is fused together, metal being added and fused to the walls of the groove until it is entirely filled up, and if necessary additional metal can be built on so as to increase the strength and dimensions far beyond what it was before. Of course, metal can be built on, though there is no break to repair, so that parts can be strengthened before they break or metal removed by accident or mistake may be replaced, defective materials and workmanship being corrected. All metals can be welded in this manner.

The reason why a temperature of 6,300 degrees is necessary, when the ordinary metals melt at not over 2,500 degrees, is due to the conductivity of the metal. One would think that the oxy-hydrogen flame which has a temperature of between 4,000 and 4,500 degrees would be sufficient to carry out this work, or even the ordinary illuminating gas and air flame used in a blow-pipe, as these flames have sufficiently high temperature to fuse the metal. The conductivity, however, is so great that the heat is drawn away from the point where the flame is supplied into the body of the metal nearly as rapidly as the heat is applied by the lower temperatured flame, with the result that a large mass of metal is brought to a red heat, instead of merely at the point where the weld is required, with the result that the part is warped out of shape or scaled so as to make it useless. With the oxy-acetylene flame, however, the heat is put into the metal so rapidly that the conductivity has not time to draw it away, with the result that metal begins to fuse when the surrounding parts two or three inches away are cool enough to handle, and before any large amount of surface is brought into action to radiate the heat. The metals of higher conductivity, of course, require a larger flame, and a greater area is heated up.

The cost of the process varies in direct proportion to the mass of metal that has to be heated up, and therefore not necessarily in accordance with the sectional area of the welds. The only reason why this high temperature is required is on account of the concentration of the heat, and, therefore, the rapid penetration at that point. It can be readily seen that where a weld has to penetrate any depth, the flame being applied to the surface will melt the metal at that point, and a continuation of the application of the flame will merely burn that metal away; and not until then will the metal below the surface be fused. It is, therefore, useless to try to make a lap weld or one of any depth, the before described method of grooving out the parts being necessary where welds of any thickness are made. The reason why the oxy-acetylene flame gives a temperature of 6,300 degrees is due to the fact that acetylene is composed of 92.8 percent of carbon and the balance hydrogen; this large amount of carbon requires a large amount of oxygen for complete combustion; and when acetylene is burning in air, sufficient

* Read before the American Institute of Steam Boiler Inspectors, Boston, Mass.

† President of the Autogenous Welding Equipment Co., Boston, Mass.

oxygen cannot be obtained for complete combustion from the one-fifth approximately of oxygen which is contained in the air. The result is that the gas has to spread out through a considerable space to obtain the necessary amount of oxygen, and therefore the temperature is brought very low, acetylene burning in air merely giving a temperature of about 1,800 degrees, whereas illuminating gas is in the neighborhood of 2,500 degrees. It will be noted when the acetylene is turned on the torch and ignited the flame has a considerable length and is very smoky; when the oxygen is turned on, the flame shortens up to about three-eighths of an inch in length, the heat being concentrated into that space, and you can readily realize the large increase of temperature thus produced. Another thing that has largely to do with the high temperature is that the four-fifths of nitrogen in the air (which flames burning with air heat up to a considerable degree, such heat being lost) is eliminated where pure oxygen is used. It will be noted that when the oxygen is turned on the torch, there are two distinct flames, one the short flame, three-eighths of an inch long, being very bright in color, and the other one, which spreads out, being not so noticeable; this is due to the fact that hydrogen and oxygen together form water, and therefore cannot unite above the dissociation point of water. The temperature of the carbon of the acetylene burning with pure oxygen being very much above this point, the hydrogen is compelled to pass through this hot flame and, uniting with the atmospheric oxygen, burns with this extended flame, it being termed the "envelope." This has two distinct advantages, one being that it keeps the nitrogen of the air from coming in contact with the hot carbon flame, and therefore cooling it; the other, that it keeps the oxygen in the air from coming in contact with the weld and oxydizing it.

The equipments consist of a cylinder of dissolved acetylene and a cylinder of oxygen, the necessary reducing valves, hose connections to the torch, the torch itself and the tips wherein the mixture is produced, and at the end of which the flame burns, the dissolved acetylene cylinder being used for portable work, whereas the high-pressure generator is used for stationary work, the acetylene being produced from calcium carbide. The peculiar feature of the equipment is the fact that it is possible to obtain a material from which a flame of 6,300 degrees of temperature can burn. That material of the tip is merely common brass. The flame does not actually touch the brass, it being projected an infinitesimal distance away, due to the pressure of the gases, and what small amount of heat is radiated back into the tip is carried off by the cool gases passing through. The process would be absolutely inoperative if it was necessary to have a tip to resist the temperature of the flame, as so far we have not come across any material which will do that.

The process of welding demonstrated to illustrate the paper is termed the Davis-Bournonville "high-pressure positive mixture" equipment, the "high-pressure" spoken of being merely the fact that the acetylene is under an appreciable pressure, not exceeding fifteen pounds, as well as the oxygen. This is taken advantage of in getting a thorough homogeneous mixture of the gases; the gases striking together at right angles in the tip, both under pressure, get a very close molecular contact; and passing down the passage in the tip to the outer air, are there ignited and burned. This type of tip uses only 1.28 of oxygen to each unit of acetylene consumed. There are other types of torches on the market called "low-pressure injector mixture" which use from 1.5 to 1.8 of oxygen to each unit of acetylene, due to the fact that the acetylene being brought in under no appreciable pressure is drawn into the mixture by the injector action of the oxygen, thus producing a stratified mixture which not only causes a loss of economy, but also largely affects the strength of the weld, due to the surplus oxygen oxydizing the material. It can also readily be seen that where acetylene is brought in by injector action, the mixture cannot be very closely regulated, whereas in the "high-pressure positive mixture" type the gases are regulated by the size of orifices through which they have to pass, both being regulated in this manner.

At the present time there are millions of dollars' worth of broken parts of machinery being thrown away which could be taken care of in this manner if those in charge had a knowledge of the possibilities of this process. It is possible to save not only considerable on the value of the part, but also large sums of money due to the reduction in time required to obtain a new part, which is often of very much more importance than the saving of the part itself. The saving to be made by this means is well illustrated by the welding of a broken automobile frame as compared with other methods of repair. An automobile frame can be welded in a few hours at comparatively small cost, but by other methods it is necessary to strip the car and replace the side member or put in a fishplate and rivet it up; then to re-assemble the car, test it out with the possibility that adjustments have been disturbed which materially affect the correct running of the car, this process generally taking about six days, and it can be seen that in the case of a commercial vehicle that the time thus expended is a very serious loss, in addition to the extra cost of carrying out the work.

The process is being extensively used by street railway companies for the repair of broken motor cases, and also for filling in the concave joints of the tracks produced by the hammer of the wheels at the joints.

The extent to which the welding of cast iron can be carried out is well illustrated by the welding of automobile cylinders in which the crown of the combustion chamber has been broken out. It is necessary to remove the section of the water jacket so as to weld the break from the outside; this section is then welded back in place and, if the part is not available to replace, a piece of sheet steel can be formed up to fit the cylinder and can be welded in place, the repair not being distinguished after it has been cleaned off. This might be termed "tracheotomy." It is possible to weld metals so that when they are machined off, the weld is indistinguishable.

Broken gear teeth can be filled in with new metal and the part recut with expensive cutters, the metal being perfectly soft and there being no fear of injuring the cutter if the work is properly carried out, the tooth being in every way as good as the one that was broken out. We have welded in teeth of a gear twenty-two-inch face, six and a half-inch pitch, fifteen feet in diameter, weighing sixteen tons; and in case of a tooth of this size, or even considerably smaller, the metal can be built up on the tooth, it not being necessary to fill in the space, as is the case with a smaller pitch.

The process can also be extensively used in manufacture along certain lines. The use is perfectly obvious for correcting errors in workmanship or design, or defects in material such as blow holes and cold laps. There is also a large amount of work to be carried out in welding up pressed steel parts. This is an age of pressed steel; but in the past there have been limits to its use, owing to the difficulty of fastening pressed steel parts together, due to their thinness. By welding them, however, a great number of parts which are now made of castings can be made of pressed steel, with great advantage both as to cost and efficiency.

Another extensive use for this process is in cutting steel and wrought iron by a jet of oxygen. It is not possible to cut cast iron by this means, owing to the free carbon in its composition. This process is really a development of the laboratory experiments of making a jar of oxygen, heating an iron wire to a red heat and inserting it in the jar of oxygen, when it will begin to glow and scintillate, and eventually be burned up; the oxy-acetylene flame is used to heat a spot of metal on which a jet of oxygen is projected from an additional supply; the oxygen combines with the red-hot metal and oxydizes away, or the metal practically burning itself through at every point where the oxygen touches it. The stream of slag coming from the first section cut, passing over the surface lower down, keeps that up to the point where the oxygen will combine with it; and that in turn is consumed, the action being progressive. This is used for such purposes as cutting irregular shapes, which cannot be cut satisfactorily by means of up-to-date labor-saving tools, such as cutting down structural iron work in position, cutting out dies, wrecking buildings of all descriptions. Pier 14 in the North River, New York, burned down a few months ago; there were over a thousand tons of twisted metal which the contractors undertook to remove in thirty days. Owing to labor conditions, they could not get sufficient men to remove the parts by ordinary means inside of six weeks, and they were under a penalty of three hundred dollars a day over the thirty days. They purchased a Davis-Bournonville "High-Pressure Positive Mixture" cutting equipment, and with eighteen men removed this metal in twenty days, as compared with the equipment of thirty-five men for six or eight weeks, by other means, the saving thus produced being ten or fifteen times the cost of the plant.

In the West a large steel construction building was burned down, the floors falling on one another and imprisoning bodies in the basement. It would be necessary to have worked at this for a month or more before the bodies would have been recovered by other means, but by use of the oxy-acetylene cutting torch the bodies were recovered within a few days.

The heat from the oxy-acetylene flame can be used for a number of purposes other than welding and cutting, such as making short heats either to straighten parts or to bend them. It can also be used for hardening parts locally, being of great advantage in the hardening of such parts as one-piece cam shafts for automobiles, the heat not penetrating sufficiently to cause trouble with the straightening of the shaft after the hardening. There are also great possibilities for the process both in welding and cutting in a machine, it being possible to weld up sheet metal and other parts in a machine very much more satisfactory than can be carried out by hand, and the cutting torch held in a machine can cut out dies and trimmer plates so accurately as to require very little machining after the operation has been carried out.

According to press reports, one of the largest locomotives in the world has been built for the Pennsylvania Railroad. It will be tried out in freight service on the steep grades of the mountains in Western Pennsylvania. From the point of the pilot to the pulling face of the coupler on the rear of the tender the distance is 98 feet 3¾ inches. The weight of the engine in working order and the tender loaded is 668,000 pounds. This is 238,000 pounds heavier than the heaviest passenger engine and 272,600 pounds heavier than the heaviest freight engine now in use by the Pennsylvania road.

It outweighs John Bull, the Pennsylvania's oldest locomotive, by 644,275 pounds. The new locomotive has four cylinders, each having a diameter of 27 inches and a stroke of 28 inches. Each of the sixteen driving wheels is 56 inches in diameter. The tender will hold 9,000 gallons of water and 30,000 pounds of coal.

An Open Letter to Boiler, Tank and Stack Manufacturers of the United States and Canada

As legislation is about to be taken up in several of the United States and a number of provinces in Canada, it behooves boiler, tank and stack manufacturers, as well as the manufacturers of material used in the construction of these several lines, to take cognizance of the coming convention of the American Boiler Manufacturers' Association in New Orleans, La., March 12 to 15, inclusive, at which time an effort will be made by the A. B. M. A. to take up and decide upon uniform specifications.

This organization has always stood for practical laws to protect the public, as well as honest and conscientious boiler manufacturers. Its first action in 1889 was to establish the specifications for boiler steel and construction which have become the standard by the general concurrence of manufacturers and engineers. Its efforts to pass uniform laws in various States have proved futile, and an educational campaign was resolved upon in 1898, and the association in convention at St. Louis unanimously adopted the uniform American specifications. These have been utilized by engineers and builders in stating their requirements.

In 1907 Massachusetts adopted a code of boiler rules in general consonance with these specifications. This code has been adopted by several States since, and is likely to be very generally enacted throughout the country. It is important that any imperfections or crudities in these rules should be frankly criticised by practical boiler manufacturers, with a view to perfecting the code and eliminating the effects of unjust or ill-considered legislation. Any individual or firm in one State would be at a disadvantage in combating an unfair bill, but deliberate and carefully considered endorsement of fair rules, or equally emphatic condemnation of unfair or extreme requirements by a body such as the A. B. M. A., with its prestige of a quarter of a century working in these lines, must and will have great weight with intelligent legislators everywhere. You cannot have failed to observe that when a matter of this kind is adopted by one State the legislation is promptly followed by similar actions in other States.

The principles of conservation and regulation are among the most vital interests now under discussion by the American people, and it devolves upon you as practical and honest boiler manufacturers, and all manufacturers and supply houses supplying boiler material, to see that this tremendous vital force is properly guided by correct information such as you can supply. We cannot urge too strongly your attendance at the coming convention in New Orleans, La., March 12 to 15, inclusive, and request you to send your name to the undersigned secretary of the Supplymen's Association, so that accommodations and arrangement for your entertainment can be made while in New Orleans.

F. B. SLOCUM,
Secretary, Supplymen's Association of the American Boiler Manufacturers' Association.
West and Calyer Streets, Brooklyn, N. Y.

The 50,000th locomotive built by the American Locomotive Company, New York, which was designed and constructed at their own expense as an experiment, is reported to have developed 2,216 horsepower, making 121.4 pounds of weight per horsepower. The boiler is fitted with top header and double-looped superheater tubes and the firebox with a "security" sectional brick arch.

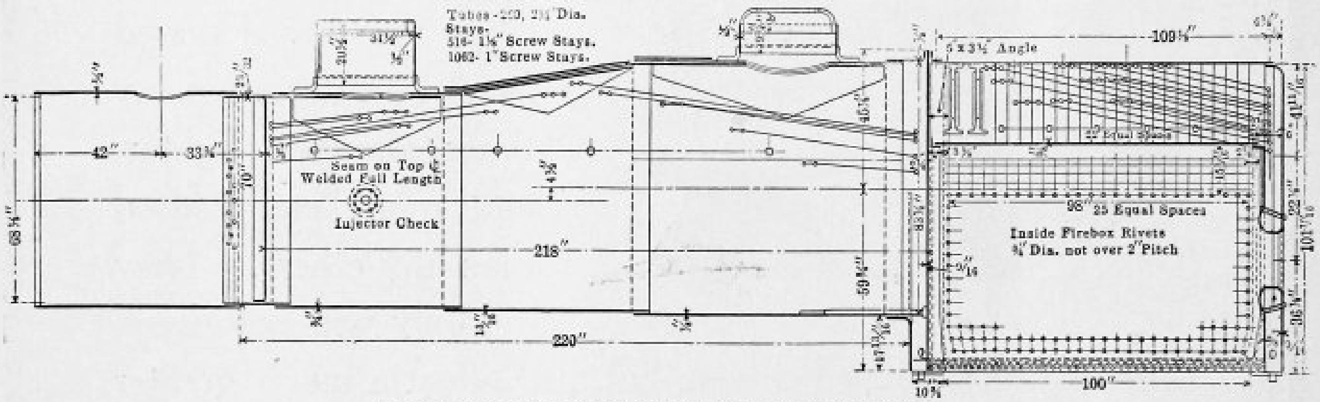
Proposed Comparative Tests Between a Staybolt Firebox and a Jacobs-Shupert Sectional Firebox

In September, 1910, certain tests were made at Topeka, Kan., under the direction of the test department of the Atchison, Topeka & Santa Fe Railway Company, which demonstrated the resistance of the Jacobs-Shupert sectional firebox to low-water conditions. It has been deemed advisable, however, to undertake a comprehensive series of tests under entirely impartial and disinterested auspices, in order to obtain accurate and scientific data regarding the efficiency, as well as the strength and resistance, of the Jacobs-Shupert sectional firebox in comparison with a similar firebox of the standard staybolt type. With this purpose in view, the Jacobs-Shupert U. S. Firebox Company secured the consent of Dr. W. F. M. Goss to act as expert to outline and afterwards direct, under his supervision, a series of tests such as would give accurate and scientific data. Upon the conclusion of the tests, the facts disclosed therein are to constitute the basis of a report by Dr. Goss.

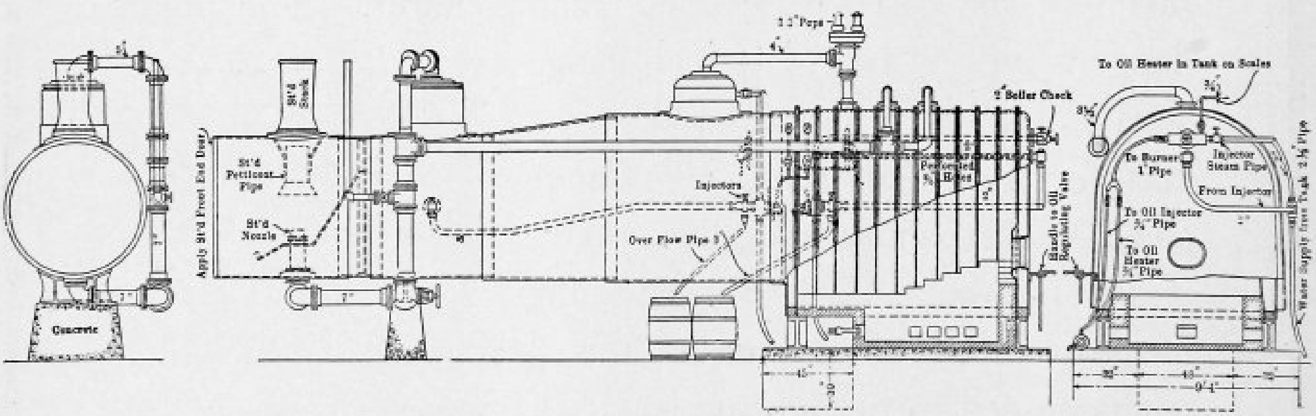
These tests are to be made in the presence of whomsoever may desire to witness them. The tests are to be conducted at Coatesville, Pa., and a special testing plant has been erected wherein the various efficiency tests hereinafter described will be made. Upon the conclusion of these efficiency tests, the boilers are to be removed to a point about one-half mile distant, and prepared for the low-water tests. Provision will be made for spectators to observe these tests without danger of injury in case of explosion.

Two boilers, identical in construction except for the fireboxes, have been provided. The principal dimensions of the two boilers are as follows:

	Jacobs-Shupert Boiler	Staybolt Boiler
Outside diameter of shell of boiler at front end.................inches	70	70
Diameter of throat of boiler......inches	83⅞	83⅞
Number of tubes.....................	290	290
Length of tubes.................inches	218	218
Diameter of tubes..............inches	2¼	2¼
Inside length of firebox.........inches	109⅝	109 11/16
Inside width of firebox.........inches	76⅜	76¼
Height of top of crown of firebox above bottom of mud ring.....inches	73 3/16	74 13/16
Number of sections composing firebox	11	..
Diameter of radial stays........inches	..	1



GENERAL DESIGN OF TEST BOILERS WITH STAYBOLT FIREBOX APPLIED



GENERAL ARRANGEMENT OF BOILER READY FOR TESTING WITH JACOBS-SHUPERT FIREBOX APPLIED

Each firebox compartment is completely isolated from its tube compartment by means of an extension of the flue sheet, and the first series of tests will concern the determination of efficiency data for each firebox independently of its tube compartment.

Upon the conclusion of the first series of tests, it will be necessary to dismount the boilers and disconnect the fireboxes and remove the blind diaphragm consisting of the extension of each flue sheet, and the boilers again will be put together and remounted on the testing plant for a second series of tests, during which, therefore, each boiler will be in its normal condition. It is estimated that about two weeks' time will elapse between the two series of tests.

FIRST SERIES OF TESTS

The first, which will begin February 1, will consist of comparative tests to determine the relative amount of heat absorbed by the fireboxes of the two boilers under similar conditions of operation. The original construction of each boiler provides a diaphragm which will separate the water space of the boiler into two compartments, one of which includes the tube surface and the other the firebox surface. In the course of the tests these compartments are to be separately fed with weighed water, an arrangement which will permit of a separate determination of the heat transmitted by the firebox and by the tubes respectively.

The series will consist of three evaporative tests upon each boiler. Tests No. 1 of this group will be made under low power; tests No. 2 will be made under average or normal power; and tests No. 3 will be made under maximum power.

It is expected that the results obtained from these tests will disclose the difference in the heat-absorbing capacities of the two fireboxes in question. The results will also give certain facts which American engineers have long wished to know with reference to the relative capacity of a unit area of firebox heating surface as compared with the capacity of a unit area of tube heating surface.

SECOND SERIES OF TESTS

After the conclusion of the first series of tests, the boilers will undergo such reconstruction as may be necessary for the removal of the diaphragms. This accomplished, they will in each case be entirely typical of normal boilers in present day service; that is, one will be a normal staybolt boiler and the other will be a normal Jacobs-Shupert boiler. Each boiler will then be subjected to a series of three evaporative tests, under rates of power similar to those employed in the first series. These tests will establish the evaporative efficiency and the capacity of the two boilers in question. In addition to data usually secured in ordinary boiler testing, it is proposed to attempt, by the use of special equipment, and also through the employment of expert assistance, to secure some information concerning conditions affecting the circulation in the two boilers. A comparison of the results of these tests should give an accurate measure of the relative performance of the two boilers under all possible rates of power.

THIRD SERIES OF TESTS

After the completion of the efficiency tests, probably about April 1, the two boilers are to be arranged for a test of strength under low water conditions. The tests of this series will hereafter be referred to as low water tests. They are to be made under conditions substantially as follows:

The boilers are to be set in a location where their explosion would result in no harm to surrounding property and are to be equipped with instruments of observation located within shelter, to provide for the safety of the observers. In the course of these tests, the boilers are always to be operated at a predetermined rate of power, which rate shall be a close approach to the maximum that the boiler is capable of delivering. Each boiler is to be subjected to a progressive series of tests until the destruction or serious deformation of the firebox occurs, the series to begin and proceed substantially as follows:

Test No. 1.—In anticipation of this test, the boiler is to be brought into action and operated under normal conditions at the predetermined rate of power. These conditions secured, the feed is to be cut off until the water reaches the level of the upper surface of the crown sheet. The feed pump will then be started and the water level restored, after which, as a precaution insuring safety to observers, the pressure in the boiler will be reduced and a careful examination made of all parts. If necessary, the boiler will be cooled and even emptied after these tests. If minor defects appear, such as leaky staybolts, they will, so far as possible, be corrected before proceeding with the next test.

Test No. 2.—Test No. 2 will be similar to Test No. 1, except that the water level will be dropped to a point one inch below the upper surface of the crown sheet.

Test No. 3.—Test No. 3 will be similar to Test No. 1, except that the water level will be reduced to a point three inches below the top of the crown sheet.

Test No. 4.—Test No. 4 will be similar to Test No. 1, except that the water level will be reduced six inches below the top of the crown sheet.

Test No. 5.—Test No. 5 will be similar to Test No. 1, except that the water level will be reduced twelve inches below the level of the crown sheet.

The series of tests will be continued for each boiler until the defects are so serious as to require the reconstruction of the firebox.

The fuel for all tests will be oil, the use of which will permit the satisfactory operation of fires during the low water tests, when the observers are at a distance from the boiler. Supplementary tests with coal are contemplated.

Engine Failures*

One of the worst troubles that can occur to a locomotive and requires patience and skill on the part of the engineer and fireman to get along with consists in leaky flues and staybolts. Flues will start leaking at times because of not carrying a bright, even fire, or by allowing banks to form in the firebox, causing temperature to rise and fall which creates expansion and contraction on flues and sheets. Short firing allows too much cold air to be drawn in near the flue sheet, with same results as above stated, which is also true when the firedoor is allowed to remain open too long when firing. Nothing will help these troubles more than intelligent work on the part of the engineer and the fireman. Much good can be done in overcoming these troubles by teaching the enginemen how detrimental such conditions are to the boiler, and the engineer, if he has interest in his work, will watch his fireman and see that he carries out such instructions.

Other causes for leaky flues are careless and irregular boiler feeding; engineers must be taught to understand and practice such boiler feeding as will maintain as even a pressure as possible on the boiler. Working an engine harder than necessary to haul the train at the desired speed very soon tells on the boiler and should be prevented. Some waters which must be used will cause flues to leak, while others will sometimes help to dry them up again. The avoiding such water as gives the most trouble from leaking will help to avoid failures. The condition of the flues, as regards keeping them clean, is one of the most important items governing the steaming of an engine, and any railway that has over ten engines leaving a roundhouse daily will make money by keeping a man to clean out flues and do it properly. The grates should also be kept in good working order. There is nothing that will play a fireman out more quickly than hard-working grates, and with such grates we usually have dirty fires, with results as formerly stated. Poor workmanship on part of the boiler makers in calking flues, or in applying them, is often the cause of leaky flues. There is no question but what they are slighted at times by these men and merely given attention enough to get them dry leaving the roundhouse. A good reliable boiler maker foreman who sees that this work is properly performed is a valuable man.

* Extract of paper read before the Northern Railway Club, published in the *Railway and Engineering Review*.

North-Eastern Railway Company's New Boiler Shop

The new boiler shop recently erected at Darlington, England, by the Northeastern Railway Company stands at the east end of the Stooperdale estate. It is 513 feet long and 219 feet wide, and these dimensions will furnish some idea of the possibilities in the way of output which can be realized in a shop having such ample proportions. Its general arrangement is shown in Fig. 2.

The columns and framework are of rolled steel joists braced together; thus, so far as support is concerned, the building is independent of the brickwork and is so arranged that extensions can, if found necessary, be readily carried out. The height to roof principals is 35 feet and to traverser rails 24 feet. The cross spans, beginning at the east side, are: two 60-foot bays, one of which is devoted to new and one to old boiler work; next, a 30-foot bay containing machinery, and another 60-foot bay at the west side devoted to tender work.

The riveting tower is situated at the southeast corner of the first 60-foot span, and includes a separate crane which runs across the shop at a height of 46 feet 6 inches from floor level, at which it is operated from hydraulic cylinders and commands the fixed riveter. This hydraulic boiler-riveting machine has a gap of 17 feet 6 inches and is capable of exerting a pressure on the rivet head of 65 tons. It is also fitted with a reducing valve, by means of which lower powers can be obtained. The machine consists of a strong iron main casting to which the cast steel hydraulic cylinder is bolted. The hob of the machine is also cast steel and is secured to the main casting by large steel bolts and nuts. It is fitted with an automatic power-saving arrangement which effects a saving of at least 60 percent of the hydraulic power required to work the machine. It also possesses a patented timing arrangement, by means of which pressure is kept on the rivet head for any period up to 45 seconds, thereby ensuring that the rivet is properly closed before the pressure is withdrawn.

The whole of the shafting—which is 3 inches in diameter—in the shop is belt driven from 45 horsepower, 440 volts, direct-current motors, these being placed in concrete foundations raised above floor level with inclined drives. Arrangements for tightening the bolts are also provided. The main shaft hangers are supported from the traverser girders and are of T steel, 6 inches by 3 inches, which forms a light, strong and economical hanger. Their shape permits of the passing of the shafting between the main columns, inside of which cast iron brackets are fixed. The countershaft girders are of Warren type bracings with channel steel as the top and bottom members, and the countershaft brackets can be moved to any position without drilling these members.

At the southeast corner of the building in a separate annex is a set of three-throw horizontal hydraulic pumps for boiler testing purposes, the plungers being 3¼ inches in diameter and having a 12-inch stroke. The pumps are capable of delivering 50 gallons of water per minute at a pressure of 1,700 pounds per square inch. They are driven by an electric motor directly through machine-cut gearing, and are fitted

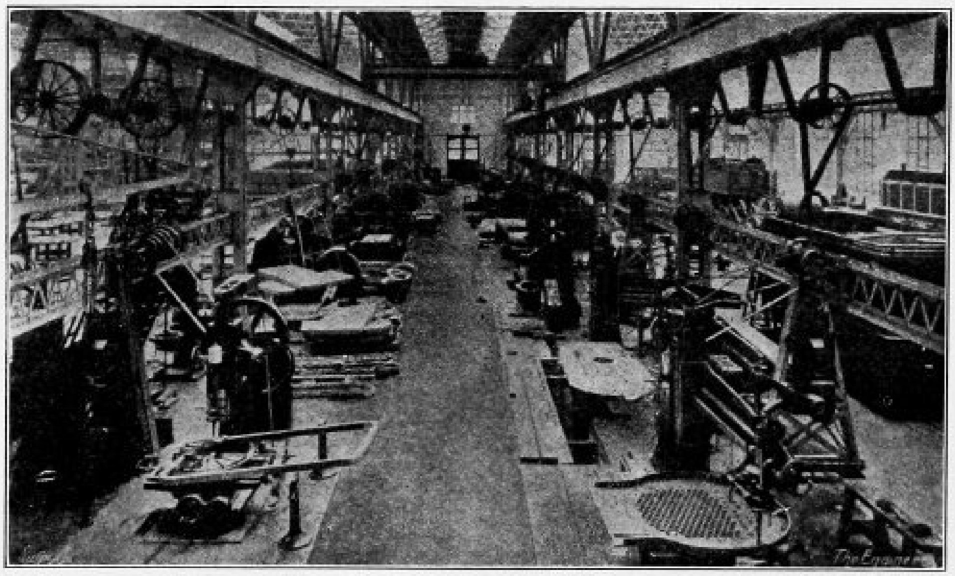


FIG. 1.—MACHINE BAY, LOOKING SOUTH

with patent automatic control gear consisting of a hydraulic cylinder which operates the electric controller for stopping the motor and pumps when the accumulator has reached its full stroke and starting them again when it has descended. In conjunction with this arrangement there is provided an automatic by-pass valve; also worked by hydraulic cylinders, so that the motor is started up at about 25 percent full load, the load thereafter coming on gradually until full load is reached. These are by Hugh Smith & Co., of Glasgow, by whom most of the heavy hydraulic machines in the works have been supplied.

The power for the pneumatic drills and calking tools is furnished by an air compressor—Brotherhood's—having a capacity of 500 cubic feet of free air per minute. The compressor is of the two-stage vertical type, running at 300 revolutions per minute, is gear-driven by a Siemens motor of 105 horsepower, and forced lubrication is supplied to all working parts. Individual motors are on certain machines as under: One of 23 horsepower on a plate-edge planing machine; one of 22 horsepower on a punching and shearing machine; one of 12 horsepower on plate rolls, and two of 10 horsepower on duplex radial-arm drilling machines. These large machines are all placed in positions most convenient for dealing with their special work.

The flow of material from its raw state to the finished product has been kept steadily in view in the laying down of the machinery. There are in the shop four 25-ton overhead electric traveling cranes with single crab and four motors of the following horsepower: Traveling, 6½ horsepower; cross travel, 2½ horsepower; heavy hoist—25 tons—10 horsepower, and light hoist—5 tons—10 horsepower. The longitudinal travel is 175 feet per minute, and cross traverse 100 feet per minute. Two of these cranes are in the new boiler building bay, and one in each of the other two 60-foot bays of the shop. In the 30-foot bay, which contains a large proportion of the machinery, are two 5-ton overhead electric traveling

One furnace is used solely for heating copper plates for flanging by hand. A tank 8 feet deep, sunk to floor level, is used for annealing after flanging.

There are three hydraulic flanging and stamping presses. The largest has a power of 300 tons. In this press the greatest width between the columns is 10 feet 1 inch, and the space between the top of the table to the top casting when the table is fully down is 7 feet. The main ram has a 3-foot 9-inch stroke, and is fitted with an internal ram giving a power of 75 tons. The top casting can be lowered on the columns 3 feet 6 inches, and the bottom casting is fitted with four vicing rams and two rams for lifting the table rapidly to its work. The other two presses are of 230 and 100 tons pressure respectively.

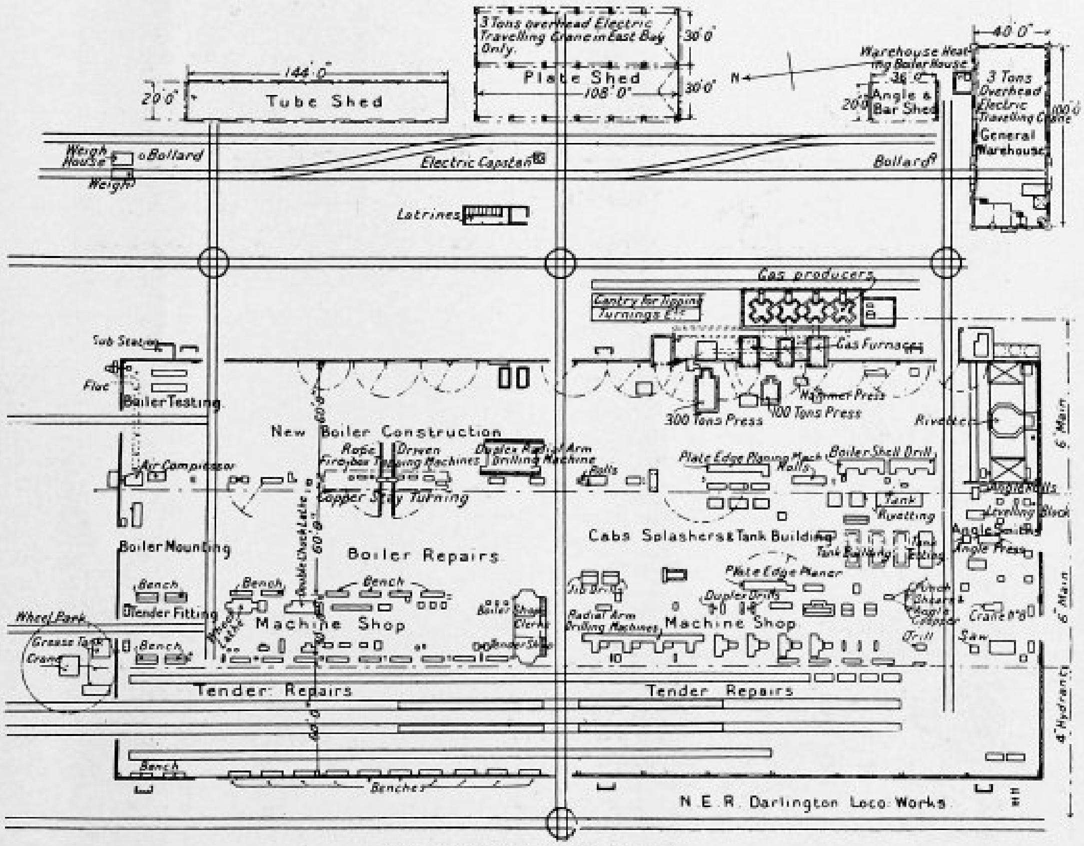


FIG. 2.—PLAN OF THE BOILER SHOP

cranes each fitted with four motors as under: Traveling, 6½ horsepower; cross travel, 2½ horsepower; heavy hoist, 10 horsepower, and light hoist, 10 horsepower. The speed of these cranes is 300 feet per minute, and they are used for the conveyance of the heavy work from the cross-over rails to any machine where it may be required. All these cranes are by Craven Brothers. In addition to these electric cranes, there are several hydraulic wall cranes of various sizes. Six of these are by Cowans, Sheldon Company, ranging from 30 cwt. to 40 cwt. capacity, and serve the different presses, while a number of wall jibs carry the portable hydraulic riveters, of which there are three. Column jibs are also provided for placing plates in the various machines.

A vertical boiler is employed to work the Roots blower which is used to obtain the necessary air pressure. There are four producers, each 8 feet diameter and 9 feet high, of the latest Wilson type, arranged with water seal for continuous running; they are sunk below ground level to facilitate the unloading of the coal. Worked from three of the producers are four large gas furnaces so constructed that only the doors are in the building, the furnaces being outside. This arrangement ensures a considerable saving of floor space.

The testing of the steaming qualities of boilers is carried out by the adoption of a system of induced draft, which has proved very satisfactory, the objectionable smoke and dirt generally associated with this work having been overcome. The boilers to be tested are placed by the overhead cranes on improvised bogies, an adjustable smoke-box is placed at the end of the tubes, the fan is started, and with this available draft any escape of smoke into the shop is prevented. By an arrangement of valves fixed on the wall, the boiler is filled with water at town pressure, after which the hydraulic test from the mains is applied at suitable pressure. If this test is satisfactorily passed, so much of the water is withdrawn and fire applied for the final test.

A nest of four rope-driven stay tapping machines has been installed close to the place where the boiler arrives for this operation. Two of these machines can work at the sides or ends of the firebox simultaneously. These tappers occupy a position adjacent to the copper stay-making department, the equipment of which comprises four of Messrs. Herbert's latest machines for quick repetition stay work, also various other machines used in the making of stays.

The position of the mangling rollers and the marking-off tables with regard to the various processes of machining can be seen from the plan, so also can the positions of the drilling, slotting, planing, sawing and milling machines. The western 60-foot bay is mainly devoted to tender tank building, and the same order has been followed here in laying down the maximum of output at the minimum of expenditure of time and labor is secured.

The shop is lighted by 70 Gilbert's flame arc lamps of 1,600 nominal candlepower, which are suspended below the girders carrying the overhead cranes and are arranged in circuits

FIG. 3.—BOILER REPAIR SHOP, LOOKING SOUTH

machinery as in the boiler shop. The angle smiths, occupying a space 60 feet by 40 feet, are provided with a set of angle-bending rollers, hydraulic press, and hydraulic bar-straightening machine. The northern half of the bay under notice is reserved for heavy boiler repairs, and provides accommodation for thirty boilers of the largest type.

The shop has been so arranged that the materials entering into the construction of a boiler pass from machine to of five lamps. On each of the 75 columns in the shop there are fixed connections for the compressed air supply to the various portable pneumatic tools, as well as a two-way socket to which portable lamps and portable motors may be connected for use inside the boilers. On 19 of the columns 32 candlepower incandescent lamps are fixed for use at night time.

The stores, from which the various classes of material necessary for boiler building are obtained, are important

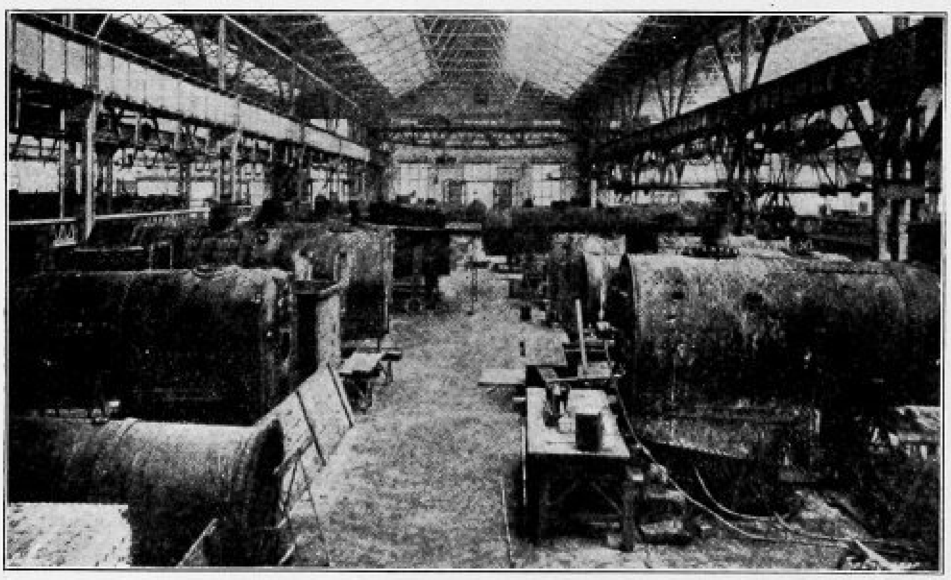


FIG. 4.—BOILER REPAIR SHOP, LOOKING NORTH

machine through the various processes of flanging, leveling, drilling, shearing, planing, rolling and riveting practically in one direction until they arrive at the south end of the east bay, a riveted boiler. Materials are delivered on a cross road in the center of the east bay, unloaded there and the wagons pass out at the west side of the shop. Thus the features, and upon them much depends to ensure expedition in working. Much care has been exercised in determining the positions of the stores and their contiguity to the shop, and also the manner of storing materials with regard to the various stages of their employment in the work of construction.—*The Engineer.*

Programme of the Twenty-Fourth A. B. M. A. Convention

At the twenty-fourth annual convention of the American Boiler Manufacturers' Association, to be held in New Orleans, March 12 to 15, the following papers will be presented for discussion:

"Rivets," by Mr. D. J. Champion, vice-president and general manager of the Champion Rivet Company, Cleveland, Ohio.

"Compressed Air and Its Uses," by Mr. Thomas Aldcorn, Chicago Pneumatic Tool Company, New York city.

"The Manufacture of Charcoal Iron Boiler Tubes," by Mr. H. A. Beale, Jr., president of the Parkesburg Iron Company, Parkesburg, Pa.

"Boiler Explosions: Their Causes and Prevention," by Mr. Francis B. Allen, vice-president of the Hartford Steam Boiler Inspection & Insurance Company, Hartford, Conn.

"The American Boiler Manufacturers' Association as It Is and as It Should Be," by Mr. W. H. S. Bateman, sales agent, Champion Rivet Company, Parkesburg Iron Company, Chicago Pneumatic Tool Company.

"Segregation of Steel," by Mr. Charles L. Huston, vice-president, Lukens Iron & Steel Company, Coatesville, Pa.

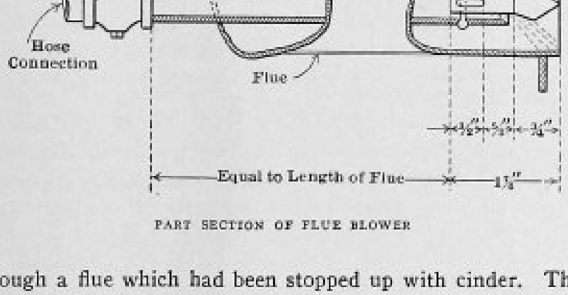
"Modern Boiler Shops and How they Should be Equipped," by Mr. H. C. Meinholtz, superintendent Heine Safety Boiler Company, St. Louis, Mo.

The question of uniform boiler laws will be taken up, and it is hoped that a set of uniform laws will be adopted at this convention. This is a question which is of greatest importance to all boiler manufacturers in the United States and Canada, and also to all insurance companies, members of the United States Government Inspection Department, as well as those of the city and State boiler inspection departments.

A ladies' auxiliary is to be formed at the New Orleans convention, and the Boiler Manufacturers and members of the Supply Men's Association are requested to bring their ladies with them, so that they make take part in the forming of this auxiliary. An excellent programme of entertainment is being provided for the visiting members and guests.

An Efficient Flue Blower

The sketch shows a flue blower which I have found gives better results than can be obtained with augers or flue blowers that work from the rear flue sheet (on locomotive boilers with 2-inch flues). For instance, I have seen two boiler washmen work for two hours to force an auger



PART SECTION OF FLUE BLOWER

through a flue which had been stopped up with cinder. They failed to get the flue open. On the other hand, when they applied the device which I am about to describe it did the work in a few minutes without any great effort on the part of the men.

The blower consists of a 1/4-inch pipe long enough to reach through the flue from the back head to the front head with a 1/4-inch stop cock to control the air. When pushing the blower through the flues the air is shut off. When the blower has been pushed through the front head, air is then turned on, dislodging the check at the end of the blower, allowing the air to strike the walls of the flue. As the blower is now pulled back through the flue toward the firedoor, the air striking the inside of the flue causes a vacuum just back of the check, pulling the dirt and cinder ahead as the blower is pulled toward the firedoor; a man on the outside shuts off the air, leaving the flue as clean as the day it was put in the boiler. It is not so with flue augers, as they leave more or less dirt laying in the flue, to arrest any which may be carried up with the draft.

I find thorough cleaning of the flues on boiler washdays leaves the engine in such shape that it will not be necessary to clean the flues again until the next washday or at intervals of thirty days.

I am pleased with the answers to my inquiry regarding buckled flue sheets and I take this opportunity for thanking your contributors very kindly, wishing THE BOILER MAKER and its worthy readers a very prosperous year for 1912.

FLUE SHEET.

Boilermaking in Scotland

The boiler makers, both land and marine, have been fairly well employed during the past year, and for certain periods it was found necessary to put on night shifts in order to cope with the work on hand. There is, however, one disappointing feature, especially in regard to land boilers; the prices obtained have been of the low order, due no doubt to keen competition for business. Obviously this means a considerable reduction of profits, and in some cases financial loss. There is another factor which is sometimes lost sight of in the excitement of business. The boiler makers in and around Glasgow have made considerable extensions to their premises within recent years, and, of course, they now require a larger percentage of orders to keep the works going full time. Like other industrial concerns they have their dull periods, which always tend to reduce prices. So far as general design and construction is concerned there is little or nothing new to put on record, and it is doubtful if a change of any sort will be witnessed in the near future. That the steam generating plant fulfills its purpose with general satisfaction may be claimed from the fact that within recent years engineering skill has been mostly devoted to scientific discoveries and improvements in other branches of mechanics. Meantime we are chiefly concerned with those bearing relationship to the steam boiler.

MECHANICAL STOKERS

In the first place we might instance mechanical stokers, which are installed in most modern boiler houses. These have been the means of giving increased efficiency by reducing the coal bill, owing to the more complete combustion obtained by using them; incidentally they relieve owners to a great extent from the ever-present dread of a visit from the smoke inspectors and the usual summons to appear in court of law. It cannot be claimed for mechanical stokers that they will in all cases do away entirely with the black smoke nuisance, as in the majority of cases it is required that boilers be forced to their utmost capacity. This entails interference with the stokers and furnace fires usually by means of a poker or slice, and thereby disturbs the best conditions in the furnace for obtaining complete combustion of the fuel. Forcing boilers is bad policy, and were more attention given to employing additional boiler power and the use of mechanical stokers there would be a large gain in efficiency all round, as well as fewer complaints regarding black smoke. Secondly, we find superheaters growing in favor among the industrial firms. There are several well-known makers who guarantee a saving of 10 to 15 percent in steam consumption, and it is of interest to note that this is one of the most recent innovations in connection with railway locomotives. Here the calculated saving is said to be over 20 percent. In the past one of the great drawbacks to the use of superheaters was their inaccessibility for cleaning and inspection purposes, but this has now been rendered easy by improvements in design. Superheaters are now included in most up-to-date boiler installations.

Prevention of Scaling

In most districts steam boilers suffer more or less from impurities in the feed-water supply. This can and should be remedied by the use of an approved system of water softening, which will prevent scale-forming matter and other impurities from entering the boiler. The prevention of these matters entering the boilers is less costly than treating them for removal after they are deposited on the plates of the boiler, and have probably caused damage to the plates as well as reduced the steaming capacity of the boiler, due to the loss of heat in penetrating the scale before radiating to the water.

Although the gas-engine makers have been active as usual in this district, the sales have been chiefly among medium-sized engines, consequently the boiler makers have suffered less from competition in that quarter.

During the year experiments have been carried out on a new design of gas producer with satisfactory results. The new plant is much simpler, less troublesome, and is said to be more economical than the present gas plant. With these qualities it will no doubt secure favor when put on the open market.

The electric motor has replaced a large number of boilers within the year, particularly of the vertical type. A number of steam engines, especially of the smaller type, have given way to the newer power, while for generating purposes the steam turbine is now taking first place. It is almost impossible to obtain delivery of a turbo-generating plant within a period of six months from the date of order.

Black Smoke

Reverting to the visible products of combustion, which undoubtedly have ill effects on the general health of the community, while laying the onus for the murky condition of the atmosphere chiefly on industry, we are apt to overlook the part played by the ordinary domestic chimney. When we consider that in a single tenement the coal consumption amounts to about 1 ton per week, we get a fair idea of what must be given off in the nature of smoke and soot from our house tops in the course of a year.

The following reports are useful in showing the actual state of the trade:

Penman & Company, Ltd., Caledonian Boiler Works, Glasgow, who make a specialty of Lancashire and Cornish type of boilers, report a slight improvement in trade during the past twelve months. Their works have been kept fairly well employed throughout the year, and at present they have sufficient orders to give them a good start after the holidays. Home orders have been more plentiful, but the export trade is still depressed.

William Wilson & Company, Lilybank Boiler Works, Glasgow, state that there has been a decided improvement during the last twelve months. Although their plant has been increased by the addition of several of the newest and best boiler makers' tools on the market, their works have been kept pretty near their full capacity for the whole year. In the home market the orders have been more freely placed, but the competition for them has been very keen, and in consequence prices have been all along kept at the low-water level. In the export trade a better state of affairs prevails, and they have booked some good orders during the year. During the past three months prices of materials have been steadily rising all round, and further increases are expected and in some cases already advised to take place after the New Year. Unless trade is upset by further strikes the prospects for the next twelve months are much better than they have been for some years back.

William Arnott & Company, Coatbridge, report a busy year and prices if anything lower, competition for business being as keen as in 1910. Among their output were six Lancashire boilers, 30 feet by 9 feet, 180 pounds working pressure, for the Warwickshire Coal Company, Ltd.; fourteen Lancashire boilers of the dish-ended type for South America, this battery being completely equipped for oil-fuel burning.

Muir & Findlay, Parkhead Boiler Works, Glasgow, report that the prospects of good trade during 1911 have been realized, their output of boilers being considerably in excess of the previous year. Prices continue low, but on account of the rises in cost of material which have been recently announced a corresponding rise in the manufactured article must follow. Meantime boiler makers seem to have a greater capability for turning out work than is warranted by the demand. A large proportion of the boilers constructed have been for shipment to India, Burmah, Straits Settlements, Philippines and South America.

Cochran & Company, Annan, Ltd., Annan, report that they have had a good year. Trade has been brisk both for home and foreign markets and for land and marine work. The recovery in freights and activity in shipbuilding have brought them their share of increased orders for donkey boilers. The ease with which the boiler is set to work, and its capacity for standing all sorts of rough conditions, are becoming better known among those interested in pioneer work in new countries, with a resulting increase in foreign business. During the year the firm have made experiments with various kinds of oil burners applied to their boilers, and have issued a catalogue showing how the boiler may be adapted for use as a donkey boiler in ships having oil-driven main engines. This work has been undertaken to keep abreast with the movement towards internal-combustion engines for marine purposes. At the moment inquiries are brisk, and they have more orders on hand than is usual at this period of the year.

Stirling Boiler Company, 45 Hope street, Glasgow, report that business during the past year has been well up to expectations and prospects for the new year are good. Orders for the Stirling watertube boiler were received from four important Scotch oil firms, various iron and steel works in this country, both coal-fired and for the utilization of waste heat. Orders were also received from the Midland Railway Company, Bournemouth Gas & Water Company, Calico Printers' Association, Sheffield Tramways, City of Bradford, Stoke-on-Trent Electricity Works, the Admiralty for Chatham and Portsmouth Dockyards, etc., besides a number of orders for sugar estates in South America, South Africa and the West Indies, match factories, textile works, mines and various other works in Denmark, Holland, Russia, Canada, India, Australia, etc.—*The Glasgow Herald.*

One of the most important fields of work for an engineer is the testing of power plants, but the study of this work has usually been confined to laboratory work in technical schools. On account of the value of the work a volume containing a careful treatise of the methods of testing various kinds of machinery is of considerable value. (**Power Plant Testing** by James Ambrose Moyer, McGraw-Hill Book Company, $4.00 net). The ability to make careful and reliable tests from which accurate data can be obtained for guaranteeing the performance of various kinds of machinery is one of the most valuable assets of an engineer.

The Boiler Maker

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Nothing is more urgently needed in connection with the boiler-making industry than uniform laws throughout the United States governing the construction and inspection of steam boilers. This is not a matter which concerns only those engaged in making boilers, but it is something which affects the good of the country and the safety of its people, and is, therefore, a national issue. Most boiler makers thoroughly understand this need, but the great mass of the population, which has the power to make and enforce such laws, has little or no knowledge of the dangers which attend faulty boiler construction and the lack of adequate inspection. Boiler explosions can, in a great measure, be prevented, as is shown by the small percentages of boiler explosions and the resulting fatalities and injuries reported annually from such countries as England and Germany, where adequate boiler laws prevail. In spite of this, however, the roll of deaths and injuries and the destruction of property from boiler explosions continues in the United States at a startling pace, and no one is held responsible for it. Is it not time for something to be done?

During the last few years several States have adopted a code of boiler rules which, in general, fulfill the requirements. Should these or similar rules be universally adopted throughout the country, a great step would have been taken towards safer and better conditions in generating power from steam boilers. But it is important that there should be a standard, as perfect as it is possible for recognized authorities to make it, to which such rules may conform. An association was formed about twenty-five years ago which adopted in its constitution a clause stating that one of its objects was to establish such standards for materials and workmanship as will insure uniform excellence of construction of all American boilers, and thus secure safety to the lives and property of all communities where boilers are used. This organization was the American Boiler Manufacturers' Association, and it has consistently followed out its purpose during its existence, establishing specifications for boiler steel and construction which have been widely utilized by engineers and builders. Now that the time has arrived when there is a possibility of boiler laws being enacted more widely throughout the country it is gratifying to note that the Boiler Manufacturers' Association, as indicated by the announcements of its forthcoming annual convention, published elsewhere in this issue, is to devote its attention particularly to the establishment of standard boiler rules, and we earnestly urge all members of the association to attend this meeting and further its work in this direction. There could be no better time to fulfill the purpose of the society than now.

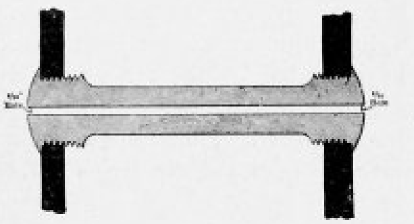
The qualifications for a staybolt inspector, outlined by Mr. Harrison in this issue, should receive the consideration of those in power to appoint men to such positions. In the first place, the staybolt inspector should be a first-class boiler maker. As pointed out by another correspondent, the practical man with technical ability is the man to be considered for a first-class boiler maker, and this applies as well to the staybolt inspector. If a staybolt isn't put in right in a boiler the inspector should be able to find it out and correct it, as well as to detect a broken bolt. Second, he should be chosen carefully for his good judgment and general intelligence. The job is a responsible one, and should be filled by a man who knows his work thoroughly and who is able to deal with serious situations as they come. No mistakes should be tolerated, and the irresponsible jack-of-all-trades who is looking for a sinecure should be given something besides a staybolt inspector's report to write his opinions on. Third, the staybolt inspector should have authority to follow up his reports and see that the proper repairs have been made, so that the engine will not be sent out in an unsafe condition and endanger the lives of the train crew and the traveling public. With the proper man on the job and a square deal from the motive power department, a possible weak point in the boiler can be made reasonably safe.

New Improved Engineering Specialties for Boiler-Making

Hollow Staybolt Iron

The increasing interest with which this material is being regarded by locomotive engineers has received marked stimulus owing to the fact that the United States Federal Government recently passed a law making a tell-tale hole compulsory in staybolts. Staybolts produced from hollow charcoal iron, it is claimed, make unfailing tell-tales on fractured or broken stays, and, furthermore, every hollow rolled stay possesses double the endurance of that made from the best solid iron. There is a danger in ordinary tell-tale drilling, owing to the fact that drilled tell-tale holes in staybolts have been found to be regularly stopped up, thus becoming a source of danger instead of an element of safety. Such a danger, it is claimed, could not possibly exist in the case of Falls hollow staybolts, as the passage of air currents through the entire stay prevents stoppage and aids combustion.

The manufacturers of the hollow staybolt iron referred to, the Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio,



point out seven distinct reasons why hollow staybolt iron should be used in the construction and repair of boilers:

(1) Because they comply with the new Federal Boiler Inspection Law, requiring that all rigid stays have a 3/16-inch hole extending in them from the outer end, and that all solid stays be regularly inspected and condition recorded.

(2) Because, while complying with the law, they save the expense and inconvenience of drilling tell-tale holes, avoid the weakness in the stay when drilled to one side or away from the center of the bolt, avoid the breakage of drills, and remove the necessity, delay and expense of hammer inspection.

(3) Because the tell-tale hole is rolled throughout the entire length of the hollow bolt in the process of manufacture, and will therefore indicate a fracture by a slight leak at both ends, instead of at one end, as in the case of the drilled hole.

(4) Because hollow stays never close up, while tell-tale holes drilled in solid stays invariably clog up with grease, sediment, etc., there being no air passing in through the drilled hole to keep it open, as is the case with hollow bolts; moreover, the suction created by the exhaust of the locomotive tends to keep open the hole in the hollow stay.

(5) Because hollow bolts are automatically inspecting at all times, and are much more reliable than any human inspector, as they give warning immediately in case of breakage by a little escaping steam at the end of the stay, while the best boiler inspectors are often deceived by uncertain sound or vibration of the sheet.

(6) Because boilers equipped with hollow bar stays can never explode or collapse from broken staybolts, inasmuch as they compel attention before any dangerous number can be broken.

(7) Because the hollow rolled staybolt, being specially flexible, possesses double the durability of that made from solid iron, and more than double the life of the average stay when drilled for tell-tale.

A New Forged Drill

The new high-speed forged drill which has been put on the market by Joseph T. Ryerson & Son, of Chicago, is entirely original in its construction and has shown remarkable results under numerous practical tests. Like the steady increase in the use of the forged shaft and forged axle, until they have become almost universal, this forged drill is the product of many experiments and trials in order to answer the increasing demand for a drill which would fulfill all requirements growing out of the use of high-speed steels.

The history and development of this drill are quite interesting. The first drill designed was a plain flat drill, used principally for rail drilling, and was a decided step in advance of other drills of the time. However, a bushing had to be used to center each size of drill in the chuck, so further experiments were performed and this fault overcome by designing the flat-beaded drill. The bead on each side of this drill engaged in grooves in the jaws of the chuck, eliminating the use of a bushing and centering the drill regardless of size. This drill was very successful and is still in use.

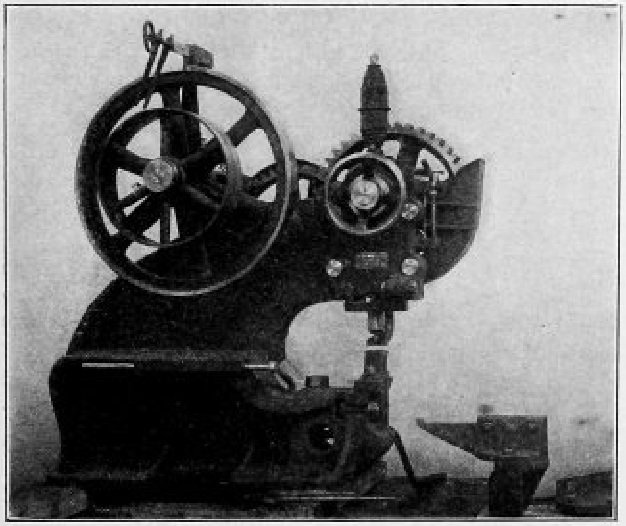
The flat twisted drill was next originated and met with exceptional success on account of its cheapness and great strength as compared with drills of other types. This drill was found suitable for rough classes of work, but did not permit drilling to exact size, a drawback which eliminated all chance of it becoming a lasting, all-round success. After many later experiments and developments, a new forged drill has been designed which at present seems to answer all requirements being made by general drill users. In manufacturing this drill the forging process is the most novel feature. All bar stock contains some dead center, and this is usually the cause of drill breakage. To eliminate any chance of such flaws this new drill is hammered or forged to shape, so that the metal becomes refined and the continuity of fibre is retained.

In producing this drill it is claimed that many objections have been overcome. By studying the drills on the market it was found that most drills if run above a certain cutting speed will heat and are found to lose their temper, no matter

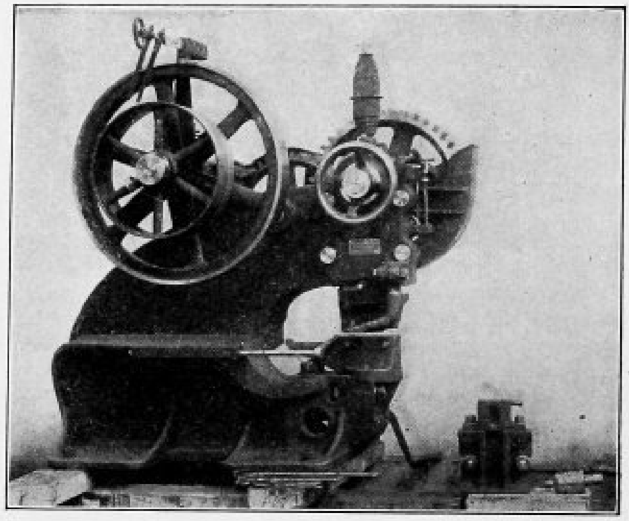
how carefully the lubricant may be applied; that it is impossible to drill hard material satisfactorily without continually re-grinding the drills, meaning a great loss in drill press capacity; that the greatest loss is the splitting up the center, which is mainly due to the dead center in the bar of steel from which the drill is made; that both loss and inconvenience are caused by the twisting off of the tang on the taper shank end; and that there is a loss of time in machine, a loss in cost of drills and the cost in paying the operator in drilling a given number of holes with drills that cannot be run at a high speed.

This new drill, it is claimed, entirely overcomes these faults. It has the same general shape and cross section as the milled drill now in use, and this style drill is acknowledged to have the best cutting qualities. However, due to the fact that any milling process destroys the continuity of fibre, the milled drill has not the strength of a twisted drill. Therefore, by combining these two, a strong, clean cutting tool is produced. By referring to the illustration it will be seen that the cutting lip is the same form as the milled drill, but that it uses minimum power. It is a simple drill to regrind, having the full cross-section of a milled drill. The clearance is the same as a milled drill, insuring perfect accuracy, while the hammering gives the strength of the twisted drill. Splitting up the center is claimed to be impossible. The steel is not milled in any way to destroy the grain, and the hammering refines the metal to such a degree that the manufacturers offer to replace any drill that splits. The raw stock is hammered to shape, thus eliminating dead center and insuring all the strength of core of a flat, twisted drill and avoiding all weakness of a milled drill. The shanks can be furnished with regular taper shank or one size larger if desired at the same price. The efficiency and economy of these drills have been shown in numerous tests to which they have been subjected.

During the past few years there has been a decided change in drilling methods and shop economies. The old slow style of drilling was superseded by driving the drill at higher speeds, thus greatly increasing the efficiency; but with the forged drill increased feed is added to high speed, producing an economical combination tending toward greater output as well as efficiency. For instance, in place of running a ⅞-inch or 1-inch high-speed drill at 400 revolutions and the usual feed, the forged drill can be run at 250 revolutions with double this feed. The use of such heavy feed permits more work in a given time, as well as the drilling of a greater number of holes for each grinding of the drill, since in using a light feed the cutting edge must be kept very sharp. Still another advantage is the fact that plain water with a little soda added to prevent rusting is recommended as a lubricant when drilling with the forged tool, and the same results are obtainable as with oil and at a less cost.



COMBINATION PUNCH AND SHEAR WITH PUNCHING ATTACHMENTS



COMBINATION PUNCH AND SHEAR WITH SHEARING ATTACHMENTS

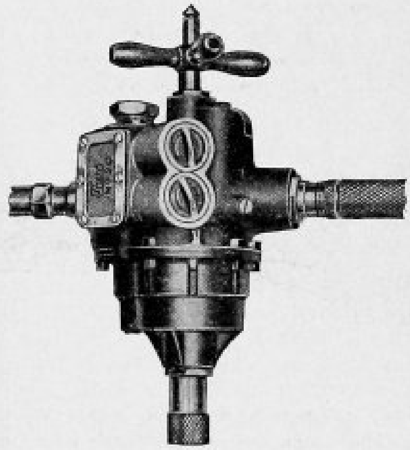
Punching Machines with Offset Frame

A machine has been placed on the market by the Wiener Machinery Company, New York, American managers of the Oeking Company, Duesseldorf, Germany, which promises to meet the demand of many shops which cannot afford special machines for use as splitting shears. The machine consists of a punch with an offset frame and interchangeable shearing blades for splitting plates of any length or width. Thus it is really a single machine which may be used either as a punch or as a splitting shear for plates of any size by simply changing the tool attachments. All other punches for the same purpose when fitted with so-called splitting blades are limited in capacity by the depth of the throat of the machine, but, with the machine which is illustrated on this page, plates of unlimited length or width can be readily cut due to the offset frame.

While two different tools are combined in one frame, each of these tools can be used as effectively as if two special machines were installed, and the user has the advantage of saving in the cost of an extra machine and also saving in floor space in the shop for accomplishing this work. The frame of the punch is similar to that of the plate shears, which are manufactured by the same company, with the exception of the fore part, which is designed for receiving punching tools as well as shearing blades. All tools are easily interchangeable and can be fastened securely.

Thor "One-Man" Drill

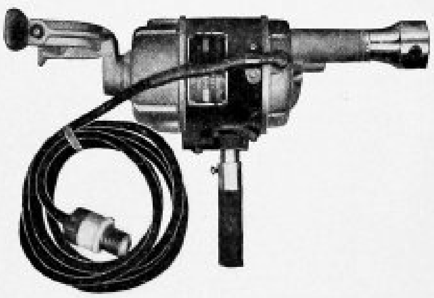
The Independent Pneumatic Tool Company, of Chicago, has recently placed on the market a new "one-man" drill, equipped with compound planetary gears, which is particularly adapted for drilling, tapping and screwing in staybolts and studs of all sizes up to 1¼ inches. Heretofore such work



required at least two, and sometimes three, men to lift and balance a portable machine with sufficient capacity to perform this work, which accounts for the new and appropriate designation of "one-man" drill. It is of course of the reversible type, weighs but 20 pounds equipped with No. 3 Morse taper socket, and, like all Thor drills, has Corliss valves with which users are familiar.

Portable Electric Drill

The illustration shows a portable electric drill, which is operated by attaching it to the ordinary incandescent lamp socket, the voltage being 110 or 220 volts, direct current, or 110 or 220 volts, 60 cycles, single-phase, alternating current. This electric drill is being used in a great many of the railroad shops for drilling 3/16-inch tell-tale holes in stay-

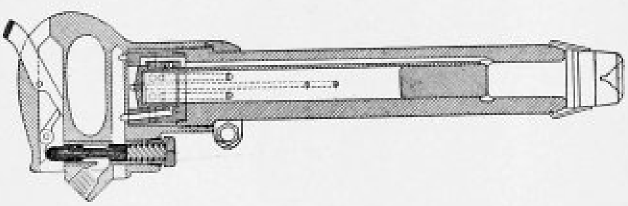


bolts. The advantage of the electric drill is that it is portable and light in weight, and can be operated off the ordinary lamp socket. Another advantage of the electric drill is that when the drill is in operation it is very steady. There is no vibration to the motor, therefore the operator will not break so many twist-drills as he will with a brace and bit or other drilling machines. This tool is manufactured by the United States Electrical Tool Company, Cincinnati, Ohio.

Oldham Long-Stroke Riveting Hammer.

Referring to the sectional view shown herewith of the long-stroke riveting hammer manufactured by George Oldham & Son Company, Frankford, Philadelphia, Pa., one of the first features which deserves notice is the arrangement of the valve mechanism, which is located wholly at one end of the cylinder. This construction allows the use of a heavy valve of large bearing surfaces, to insure strength and good wearing qualities. The cup-shaped valve moves in the same direction as the piston or hammer, where in most other riveters the valve moves in the opposite direction from the piston. It is claimed that with this arrangement it is impossible to short-stroke the hammer.

The valve itself is moved and held positively in one direction by live air and in the opposite direction by the momentum of the piston. Thus when the hammer is traveling backwards it is impossible under working conditions for the valve to



change earlier than it should, as it is held down by its own weight, also a pressure of air on a large area in the rear of the valve. The piston itself is shot back with sufficient force to overcome the weight and the pressure of air on the large area of the valve, and when the piston enters the valve it will trap a body of air within the cup-shaped valve, and will compress this volume of air to such an extent that an air buffer is formed within the valve. The valve and piston then move backwards in unison by reason of the momentum of the piston to the full extent of the stroke of the valve. This construction, it is claimed, reduces the vibration to a minimum and makes it impossible to short-stroke the piston or hammer.

A unique device is also used for preventing the handle from working loose. It consists of a clamp, which it is claimed relieves the handle from all strains and prevents it from moving. Should it become broken or damaged it can be replaced at small cost.

Personal

ROBERT LEATON, boiler inspector of the Atchison, Topeka & Sante Fe at Cleburne, Tex., has been appointed foreman of the new shops at Sweetwater, Tex.

RAYMOND A. ALLARD, formerly layer out for the Dover Boiler Works, Dover, N. J., is now foreman of the iron department of the Frank Trenkhorst Manufacturing Company, Chicago, Ill.

J. NICHOLAS, formerly traveling boiler inspector of the Cincinnati, Hamilton & Dayton Railway Company, has resigned his position to become General Boiler Inspector of the Pere Marquette Railway, with headquarters at Grand Rapids, Mich.

C. W. CROSS, superintendent of apprentices of the New York Central Lines, at New York, has been transferred to Chicago. Henry Gardner, now assistant superintendent of apprentices at New York City, will be in charge of the apprenticeship work on the New York Central & Hudson River.

New Baldwin Locomotive Works

It is reported in *The Iron Age* that Samuel M. Vauclain, vice-president of the Baldwin Locomotive Works, Philadelphia, has confirmed the report of the purchase by that company of 370 acres of land at Calumet in the East Chicago, Ill., district for the site of a Western plant this company will build. The site joins the western line of Gary, and Mr. Vauclain states that, as in the past, the procedure of this company will be conservative and the work which is in contemplation will progress as the business of the country will warrant. If the present depression in business should continue, progress will naturally be slow, and if business should revive, and the works be called upon for their maximum capacity of output, the progress would be more rapid.

It is the intention of the company to start with the erection of shops to handle similar work which is now being carried out at Burnham and Eddystone, having a capacity of output of raw material sufficient for ten modern locomotives of the largest type per week.

As soon as these shops are finished, and in working order, so that raw material can be furnished, the finishing departments, the erection of suitable machine and erecting shops for the completion of the ten locomotives will be ordered and put in operation. When this is done, which it is hoped will be at an early date, the shops should furnish employment to at least 5,000 men. The object in purchasing the 370 acres of ground is to provide room for the extension of the works by adding, as soon as suitable accommodations can be provided for workmen, transportation facilities developed, and, as advantageous business offers, additional units of ten engines weekly capacity each, until the plant has a capacity of thirty finished locomotives weekly, and the manufacture of all the forgings and castings in their shops therein employing from 12,000 to 15,000 men, depending upon the development which the art of locomotive building may have attained at that time.

Communications of Interest from Practical Boiler Makers

Talks to Young Boiler Makers

Before I explain the test of a boiler by water-pressure, I wish to set young boiler makers straight on an idea that I find very common among them, as well as in other trades; one which, if understood, would have saved hundreds as well as thousands of dollars in the past. It is the idea that you can by any mechanical contrivance *gain* power.

You see a man put a pry, or lever, under one side of a heavy object, say under the edge of a heavy firebox, and he can lift one end of the boiler. We know he could not do this even if he could get hold of the boiler, so it is argued that by the use of the lever he has *gained* power. Not at all. What he has gained is convenience.

Where you get mixed is that you do not note that the man on the long end of the lever moves a great distance, while the boiler is lifted only a very short distance.

Here we have, in Fig. 1, a lever eleven feet long; one foot from the end is a chock; it is called a fulcrum. Ten feet therefore sticks out; at the end of this ten feet a boiler maker who weighs two hundred pounds puts his weight. How much will he lift at the short end? He will lift just ten times his own weight, or 2,000 pounds. Now, why has he not gained power? Because in lifting the weight he moves it only a very short distance, while he moves a considerable distance. Our example shows that the 2,000-pound weight moves one-half foot, while the 200-pound man moves five feet, or ten times as far; as, no matter how we try, we can only get an equal amount of power on each side of the fulcrum.

200 pounds multiplied by a movement of 5 feet = 1,000.

2,000 pounds multiplied by a movement of one-half foot = 1,000.

2,000 pounds multiplied by 1 foot (the short end of the lever) = 2,000.

200 pounds multiplied by 10 feet (the long end of the lever) = 2,000.

In the case of the lever we have no friction to contend with; but when we come to gears, friction has to be considered. A pinion and gear is only a circular lever, as Fig. 2 will show.

The pinion *a* has a circumference of 1 foot on the pitch line, while the gear *b* has a circumference of 10 feet on the pitch line. Now, the pitch line is a little difficult to explain, but it is a circular line which is not quite half the distance from the top of the tooth to the bottom, and we calculate gears from the pitch line. Gearing is a very interesting study; but boiler makers do not make gears, so I will not go into the subject.

If we rolled the pinion *a* on its pitch line along a straight edge just one revolution, starting from the end of the lever, and made a mark, and starting from this mark rolled the large gear one revolution along the straight edge and made a mark and cut the lever off there, we would find that we had just one foot from the end of the lever to the fulcrum and ten feet from the fulcrum to the outboard end of the lever. This is just what we had in Fig. 1. Now, if you put a handle on the pinion and revolved it one revolution, you would turn the gear only one-tenth of a revolution; so, to make the gear turn one turn you would have to turn the pinion ten times.

A mark on the pitch line of the pinion in ten turns would travel just as far as a mark on the pitch line of the gear.

You will therefore see that you would have the same condition as in Fig. 1, and all you would gain would be convenience and, owing to the friction of the bearing, would not do quite as well as you did with the lever.

So get it out of your head that power can be gained.

About the water test or, as it is often called, hydraulic test. Water is familiar to all, and it has some very peculiar qualities, one of which is that it cannot be compressed to any appreciable extent. This quality is taken advantage of in a water test.

The first thing in making a water test is to get the boiler completely full of water; if this is not done and air is trapped in the dome or elsewhere, the test cannot be well made, as air is compressible and acts like a spring; so when you force down the plunger of the test pump, the spring of the trapped air forces the water back past the check valve

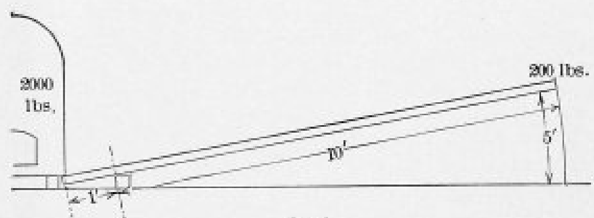


Fig. 1

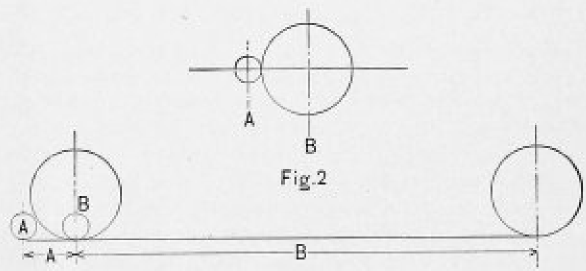


Fig. 2

of the pump before it can close, so no pressure is pumped up.

As water cannot be compressed and the particles of water move very freely on each other, any pressure put upon a boiler completely full of water is transmitted or carried to all parts of the boiler.

If you have a test pump with a plunger with an area of just one inch and you press down on it with a pressure of 100 pounds, that 100 pounds pressure is put upon every square inch on the inside of the boiler, and you can see that care should be taken not to put too much pressure on the pump, as can easily be done, as the boiler is liable to become strained and made unsafe by so doing.

You understand, of course, that a gage must be put on the boiler to show the pressure, and the gage must be compared from time to time with a standard or it may register wrong and cause trouble.

The gage is made upon a very simple principle, which is that water under pressure entering a tube, which has one end closed and is bent in a circle, will try to straighten out the tube. You will, perhaps, have noticed this in laying a garden hose in curves; when you turn the water on, the nozzle will move and the hose try to straighten out.

I have been asked to say something about the ordinary calculations which will show how much water a boiler will hold, what the water will weigh, and how many gallons there are in it.

This is all very easy, and I will begin with a square tank instead of a round boiler.

To find out how many cubic feet there are in a tank you multiply the length by the breadth and this result by the height as, for instance, a tank 6 feet long by 4 feet wide and 8 feet high would give $6 \times 4 = 24$, and $24 \times 8 = 192$ cubic feet. It would not make any difference whether you multiplied the height by the width and that result by the length; so you can say, to get the contents for a square or oblong tank in cubic feet you multiply all its dimensions together.

You have 192 cubic feet of water. To get its weight you multiply it by 62½ pounds, which is practically the weight of one cubic foot of water. It is easier to write the weight of water in decimals like this, 62.5. Now, $192 \times 62.5 = 12{,}000$ pounds.

If you want to know how many gallons there are in 192 cubic feet you multiply 192 by 7.48, the number of gallons in a cubic foot. Here we would have $192 \times 7.48 = 1{,}436.16$ gallons. The pressure of the water on the bottom is found by multiplying the area of the bottom by the height of the water in feet and this answer by the weight of a cubic foot of water; here we would have $6 \times 4 = 24$; $24 \times 8 = 192$; $192 \times 62.5 = 12{,}000$ pounds. So you see, when you get the weight of water you, of course, get the pressure on the bottom of your tank.

If you want the total pressure on the sides of the tank you multiply the area of the bottom by half the height; here we would have $6 \times 4 = 24$; $24 \times 4 = 96$; $96 \times 62.5 = 6{,}000$. The entire pressure against the bottom and sides of the tank is taken at three times the weight of the water, or $12{,}000 \times 3 = 36{,}000$ pounds.

When you come to round tanks you use a certain figure or constant; it is 3,14159. It is usually taken at 3.1416; it is sometimes called the "Magic" figure, and in mathematics is called Pe or Pi, and the Greek letter π is used to designate it, so as to save writing out all five figures in full.

Tables are published which give the areas of circles, but if you do not have one, to get the area of a circle you multiply the radius by itself—that is called squaring—and this result of 3.1416 or π. We will take an eight-foot diameter of tank, $4 \times 4 = 16$. We then multiply this number by 3.1416 and we have 50.26.

Our height will be 10 feet, so $10 \times 50.26 = 502.60$, which is of course cubic feet. Multiply by $62.5 = 31{,}412.50$ pounds or $502.60 \times 7.48 = 3{,}759.45$ gallons.

What I want young boiler makers to remember is a cubic foot of water weighs 62½ pounds.

That the number of gallons in a cubic foot is 7.48, say roughly 7½ pounds.

One thing more: that a gallon of water weighs 8 1/3 pounds, or 8.3356, to be exact. W. D. F.

Plain Talks

I have had the pleasure of reading in your October issue an article entitled "Something for the Boys in the Shop to Read." Too much cannot be said upon this subject, and I would like to see more of it in each issue of your journal. I think it would be of advantage all around to devote a few pages of each issue to plain talks to the apprentice boys and boiler makers. When I say the boiler makers, I am referring to that class of men who never had the advantages of a common school education. While we have some smart men in our craft, we also have a large number of mechanics that you can educate further in the boiler making line by complying with the above request.

I have noticed from time to time short articles or talks along the plain talk line that were very educational for this class of mechanics; also a few layouts, one in particular by Mr. J. N. Heltzel, entitled, "Duplicating an Old Flue Sheet" (May, 1910). I am not condemning our present plans of layouts, for some of them are second to none. However, I consider them along the technical line and too deep for the majority of boiler makers and apprentice boys.

In view of the fact that I have been an apprentice boy and have also enlightened my mental faculties along the technical line of modern boiler construction and repairs, I consider myself qualified to express my opinions both ways. Well do I remember the first issue of THE BOILER MAKER that came to my observation. I had occasion to go into the boss' office for an order for material. Therein my attention was attracted by the illuminating color of the cover page. As I glanced at the headlines, the word boiler maker seemed to stand out in letters as large as a house. You can't imagine the impression or meaning of the word as it appears to the apprentice boy. The clerk came to my assistance by stating that if I were interested in the publication I might look it over at the noon hour, providing I did not get it dirty, as it belonged to the boss.

Noon hour came; my appetite had deserted me, but I ate my lunch simply because I had it for that purpose. My chief object in view was the layout plans, which I immediately began to study; but they were too deep for me, so I passed on to the pictures, which were very interesting indeed. Some of the illustrations gave out detailed explanations along the plain talk line and made a hit with me, whereupon I made up my mind to subscribe for the journal, thereby to gather as much information together as possible from what I could understand, and to study out what appeared to me a conglomerated mass in the shape of laying out plans.

I have had boiler makers come to me for points of information regarding the best plans for laying out. My answer has always been "the most simple or the easiest to understand," which would bring forth the inquiry, "Where will I get the dope?" To this I would say "Books on laying out and boiler making, correspondence schools with the boiler makers' journal as a helper." By pronouncing the journal as a helper I do not mean that it is second to other publications along this line, for I know of no other as having its equal. However, I will state it is a large factor in helping a student in the layout questions, coupled with other information he can obtain from its pages pertaining to modern boiler construction and repairs.

I have heard boiler makers and apprentices make statements as follows: "Oh, I can't understand that layout dope. It's all Greek to me." Now, Mr. Editor, if you will please solicit the assistance of the plain talk writers and slip in a few pages of this talk, I think you will greatly increase the value of the journal to the majority of the readers. To reach the majority of the working class and bring results, we will have to meet them in overalls illustrated with plain talks. I also wish to convey the impression upon our modern apprentice boys and progressive boiler makers that the practical man with technical ability is the man to be considered. Craftsmen, sit up and take notice. The government and railroads want men of this caliber.

The fact that the Federal inspection law has been passed and is in force convinces me that the field for competent boiler inspectors is large. Progressive railroads must have a man with the following qualifications: ability to confer with the government officials in behalf of the companies' interests; a practical and technical knowledge of modern boiler construction, testing, operation and repair; ability to originate forms that will be authoritative, showing detailed information of performances and operation of boilers upon a moment's notice; also ability to systematize this work, thereby eliminating the unnecessary tying up of power in back shops and roundhouses. George L. Price.

Oskaloosa, Iowa.

The Staybolt Inspector

Just a plea for the staybolt inspector, the faithful, painstaking, observant, common, every-day boiler maker, the Johnny on the spot with his keen ear ever on the alert to detect a fractured or broken staybolt. Now, sir, having traveled very extensively over this country, I have taken pains to observe the work done by various inspectors, all of them invested with authority to condemn or put out of service any boiler they may consider unsafe until repairs have been made to render that boiler safe for further service. Some of these men knew nothing about boiler making, being engineers. On one occasion I stood by and saw one test a small vertical boiler for nearly an hour. He and his assistants pumped, trying to get a pressure of 100 pounds, but failed to do so on account of a crack in the head and leaking joints. Yet he gave a certificate to carry 100 pounds of steam on that boiler, and later the same man, who by the way was appointed by the Governor of the State, gave a certificate to carry 90 pounds of steam on another small boiler of the same type, but when the boiler was fired up it leaked so badly that when the poor old staybolt inspector was called upon to see what was wrong, he found the boiler unsafe for further service and upon making his report to that effect the boiler was hauled out and scrapped. These are but two cases out of many others that have come under my observation.

Yet how often are the reports of the staybolt inspector heeded as the reports of the State, County or insurance inspectors are? Seldom or never, for after making an examination and reporting his finding to his foreman, that is the end of it as far as he is concerned, having no power to follow up the report. In many cases when short of power the engine is fired up and sent out on the road, perhaps to haul a passenger train and endanger the lives of both passengers and crew.

I know of a roundhouse foreman who approached the staybolt inspector with a plan to suppress the findings of broken bolts until such times that he could lay the engine in to make repairs, yet there was a notice hung up in the roundhouse to the effect that there were one broken staybolt in the top row, two broken staybolts in the second row and five broken bolts within a radius of 18 inches—cause enough to shop any engine regardless of everything. The inspector refused to comply with his request, with the result that things were made very uncomfortable for him; that he did not last long, and eventually he lost his job and his 10 years of faithful service went for nothing simply because he had no standing.

Now, Mr. Editor, I think that the staybolt inspector should be a first-class boiler maker, selected for his good judgment and general intelligence, either by competitive examination or by appointment by the motive power department, with authority not only to make examinations of boilers but to follow up his reports when made, and to see that the proper repairs have been made, thus showing the roundhouse foreman or others handling the steam power that they cannot use engines that are not in a safe condition to work and endanger the lives of the traveling public.

In conclusion I would say, give the staybolt inspector a square deal, put him on a firm foundation and sustain him in his good work. G. H. Harrison.

Pittsburg, Pa.

"Sayings and Ten Rules of Cyrus Simmons"

The author of the epigrammatic "Sayings" and "Rules" which appear in page 32 of the January issue of The Boiler Maker certainly knows men and things, to put it tersely. I cannot let the occasion go by without having my little "say" in relation to just one of the "Sayings" and two of the "Rules," because they fit all men at some time during their lives.

"You may have a good brain, a clear vision, a dogged will, deft hands and far-flung courage, but you can't utilize your gifts to the best advantage until someone who knows better has shown you how to handle them properly." How true! But how few who really believe all that is contained in that "saying"! This, at a single stroke, sweeps away the idea that there is such a thing as a self-made man, and shows how much we really must depend upon others.

There is no such thing as a self-made man, for it is very evident that all men are in some degree dependent upon one another. It is a mighty good thing that we are so dependent; for if we were not, we could not possibly attain to anything near like perfection, and chaos would surely rule. We must learn that there are some of our fellows who are better than we are; but if we are willing to see and acknowledge this fact, we in our turn will take their places and be the "better" men to an oncoming generation who will just as surely need us as we did those from whom we learned. And so the dependence goes on, and will continue going on till the end of time.

Rule 6 says, "It takes a lot of time to be an expert on any subject. You can't possibly be an authority on the fashions and follow the latest styles in work," which means, that no man can be master of his business, trade, profession, or anything by which he "makes a living," as we say, without devoting pretty nearly all of his time and energy to that business. The man who is content to always leave his work behind him at the end of his working day cannot possibly amount to very much, for he has to compete with the fellows who *do* take their work home with them, and who are continually striving for self-improvement and advancement. These latter are always ahead in the race, when measured in terms of *real* success.

"If your work does not show your age, I don't care a tinker's dam if you're gray-haired. I buy what's in your head, not what's on it." So reads Rule 10. What a rebuke to those corporations and those employers who pretend to think a man is no more use after forty, fifty or sixty years have gone over his head, as the case may be! Just as though a man's usefulness could suddenly cease at a foreordained day and date. There is an old saying which, in part, is, "A man is as old as he feels." The numerals which represent the years of his life are significant of nothing in particular except as for purposes of reference and statistics. A man may keep young in feeling and in spirit by living a temperate and orderly life, by thinking young, and by keeping alive to what is going on in the world, and by not allowing himself to sink into the slumber of advancing years. Just think of the late Charles H. Haswell, that prominent engineer of his time, who lived to be ninety-seven years of age, and practically died in harness with his boots on, an example of a ripe and fertile mind in an aged encasement; whose advice was valued almost up to the hour he died! Why, a man at fifty is, or as nature intended, in his prime! Just in the midst of his usefulness, instead of having done with it as some would have us think.

Been too extravagant, too idealistic in my ideas of the "Sayings" and "Rules" referred to? In the language of the day, "Not on your life!" Try the shoe on your own foot, reader, and see how it fits. Charles J. Mason.

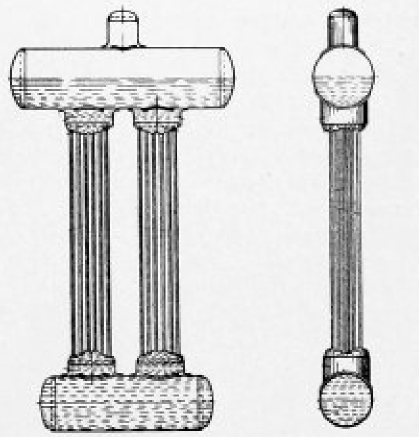
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,005,333. WATER-TUBE STEAM BOILER WITH TUBES CONNECTING THE UPPER AND LOWER SHELLS. WALTER SCHREIER, OF COTTBUS, GERMANY.

Claim 1.—A boiler comprising upper and lower drums having openings therein, a series of tubes for connecting said drums, sockets projecting



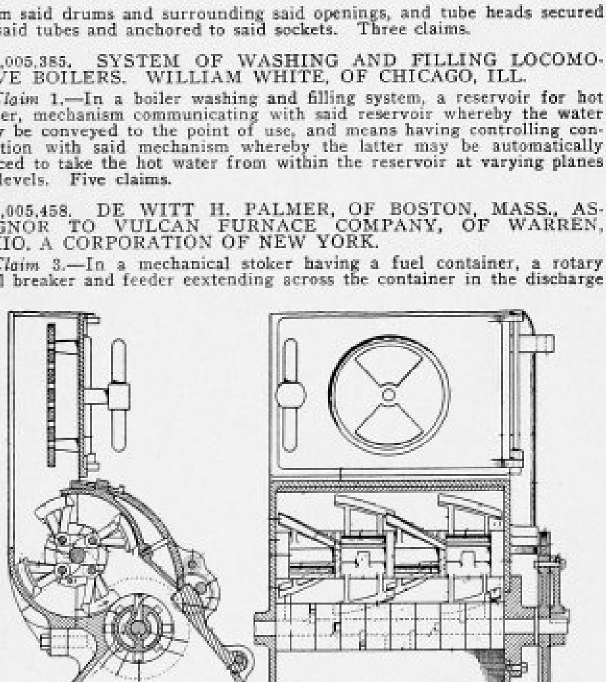
from said drums and surrounding said openings, and tube heads secured to said tubes and anchored to said sockets. Three claims.

1,005,385. SYSTEM OF WASHING AND FILLING LOCOMOTIVE BOILERS. WILLIAM WHITE, OF CHICAGO, ILL.

Claim 1.—In a boiler washing and filling system, a reservoir for hot water, mechanism communicating with said reservoir whereby the water may be conveyed to the point of use, and means having controlling connection with said mechanism whereby the latter may be automatically forced to take the hot water from within the reservoir at varying planes or levels. Five claims.

1,005,458. DE WITT H. PALMER, OF BOSTON, MASS., ASSIGNOR TO VULCAN FURNACE COMPANY, OF WARREN, OHIO, A CORPORATION OF NEW YORK.

Claim 3.—In a mechanical stoker having a fuel container, a rotary fuel breaker and feeder eextending across the container in the discharge



opening thereof and consisting of a shaft, hubs keyed thereon, each having a radial slot, pins or bars contained in said slots, and means for locking said bars in said slots, said bars extending beyond the peripheries of the hubs to constitute teeth. Eleven claims.

1,005,593. BOILER. WILLIAM ANDREW BREWSTER, OF VICTORIA, B. C., CANADA.

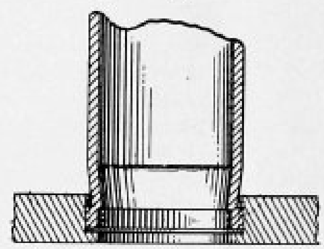
Claim 2.—A water-tube boiler comprising a casing including front, rear and side wall members, linings adjacent to the said end rear wall members terminating below the upper edges of said wall members, a rear water box supporting the rear lining and having an aperture communicating with an aperture in the rear wall member, a closure for said apertures, a top water box supported upon the linings and confined between the upper ends of the wall members, inclined tubes connecting the top water box with the rear water box, a fire box within the casing, and inclined deflectors associated with the fire box and with the top water box to support the inclined tubes. Two claims.

1,005,711. GENERATING STEAM. WALTER LYULPH JOHNSON, OF MIDDLESBROUGH, ENGLAND, ASSIGNOR OF ONE-HALF TO BELL BROTHERS, LIMITED, OF MIDDLESBROUGH, ENGLAND.

Claim 1.—A process of generating steam which comprises the step of pouring molten slag into water to which milk of lime has been added. Three claims.

1,005,760. FLUE SHEET. JOSHUA WORKMAN, OF FORT CLAY, W. VA., ASSIGNOR OF ONE-HALF TO SILAS D. TALIOFARRO, OF SALEM, VA.

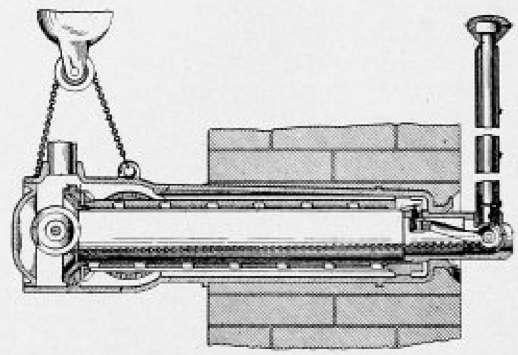
Claim.—A flue sheet having an internal endless groove, an opening being formed in the front face of the sheet communicating with the groove, and an opening being formed in the rear face of the sheet communicating with the groove and of less diameter than the first-named opening, with resultant flanges on opposite sides of the groove of un-



equal height from the floor of the groove, in combination with a flue having an end passed through the opening in the rear face of the sheet and provided with a flange of a shape and size to slidingly fit in said groove and be limited in movement by said flanges during expansion and contraction of said flue.

1,006,019. BLOWER FOR BOILERS. EDWARD K. STANDISH, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY COMPANY, OF DETROIT, MICH., A COPARTNERSHIP.

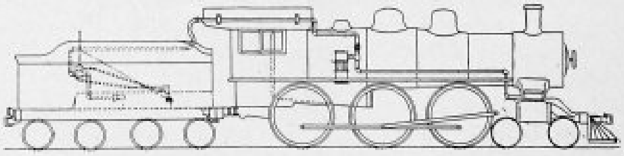
Claim 1.—A blower for boilers comprising a substantially cylindrical casing having a closed outer end provided with a steam inlet nipple and an open inner end, a barrel rotatable in the casing provided with a screw thread whose groove forms an opening through the shell of the barrel, a sleeve longitudinally reciprocable in the barrel provided with a laterally



projecting member non-rotatably interlocking the sleeve and casing and engaging the screw thread of the barrel, a tubular extension articulated at its inner end to the adjacent end of the sleeve to swing into a plane transverse to the sleeve, and provided with lateral steam jets, a hollow arm in telescopic engagement with the extension provided with a head having a steam jet, means for retracting the arm into the extension, and means for ratating the barrel. Thirteen claims.

1,006,935. FEED-WATER HEATER. THORWALD E. GRAHN, OF CLEVELAND, OHIO, ASSIGNOR OF ONE-THIRD TO LE GRAND PARISH, OF NEW YORK, N. Y., AND ONE-THIRD TO HENRY H. VAUGHAN, OF MONTREAL, CANADA.

Claim 1.—In combination in a feed-water heater, a main tank, a heating tank therein communicating therewith, a check valve for permitting



an inflow into the heating tank from the main tank, but preventing a back flow, steam heating means for supplying heat to the heating tank, and an outlet from the heating tank. Seven claims.

1,006,709. BOILER-INJECTOR CHECK-TURRET. FRANK M. A'HEARN AND PAUL S. WINTER, OF GREENVILLE, PA.

Claim 2.—A spraying nozzle for injector check turrets having horizontally-flaring opening sprovided with downwardly-inclined walls having curved outer edges, the upper portions of said walls being arranged in intersecting planes. Two claims.

THE BOILER MAKER

MARCH, 1912

Notes on the Design of Cylindrical Tanks and Boilers

BY F. A. GARRETT

It is intended in the following article to describe, as briefly as possible, the principles which govern the design of cylindrical parts for boilers and also to discuss the relative efficiencies of riveted joints. Before we can design a cylindrical part for a boiler we require to know the pressure to which it will be subjected, the ultimate strength of the material which we are going to use in its construction, and the factor of safety which we are going to assume in the calculation. For an illustrative example let us assume:

D = internal diameter in inches = 16 feet = 192 inches.

P = working pressure, pounds per square inch, = 200.

l = length of shell in inches.

f_t = ultimate tensile strength of the material in pounds = 62,720 pounds per square inch.

F_s = factor of safety. The following are good average values: 4.5 when material and workmanship are of the best; subject to the following additions: .25 when rivets are not good and fair in the girth seam; .5 when rivets are not good and fair in the longitudinal seam; 1.00 when joint is only single-riveted; 2.00 when material and workmanship are not satisfactory.

This factor of safety is equal to $\dfrac{\text{Ultimate Strength}}{\text{Working Stress}}$.

For our example $F_s = 4.5$, then $\dfrac{62{,}720}{4.5} = 13937.7$ pounds per square inch safe stress on material.

Fig. 1 represents a cylindrical boiler shell without joints. Suppose we subject it to a pressure of 200 pounds per square inch. What stress will be produced at any two diametrically opposite points such as *A A* or *B B*, i. e., the tending to tear the shell apart?

The *pressure acts radially* in the direction of the arrows of Fig. 1, which by the usual formula produces a stress at any two such points equal to

$$\text{Stress} = P \times D \times l. \qquad (1)$$

Assuming a length l of 12 inches, and putting in the other values,

$$\text{stress} = 200 \times 192 \times 12 = 460{,}800 \text{ pounds}.$$

But the pressure due to the radial forces is equal to

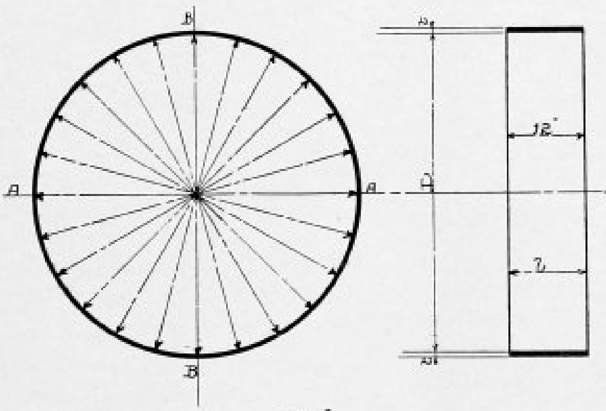


FIG. 1

$$\frac{3.1416 \times D \times P \times l}{2} = \text{pressure on semi-circumference.} \qquad (2)$$

This equals

$$\frac{200 \times 192 \times 12 \times 3.1416}{2} = 723{,}824.64 \text{ pounds pressure.}$$

How is it that this total pressure of the above amount, due to the radial forces, produces a *resultant* stress of only 460,800 pounds? Let us investigate.

It is easy to prove that if we have a force acting at an angle to a given line, as shown in Fig. 2, it will produce a certain force in the direction *O X* and another certain force in the direction *O N*. For instance, let the force *O F* of Fig. 2 equal 2 pounds, and the angle at which it acts to the horizontal equal 60 degrees. To find the two *resultant* forces by which we can replace it, or, rather, the forces which will be produced in the directions *O X* and *O N*, draw the line *A B*, Fig. 3, parallel to *O F* of Fig. 2, so that its length represents 2 pounds to some scale say, 1 inch = 1 pound. From the point

A draw the horizontal line $A\ C$ parallel to $O\ N$. Then draw the vertical line $C\ B$ parallel to the line $O\ X$, cutting $A\ B$ at B. The length of the line $A\ C$ represents to scale the force in the horizontal direction $O\ N$, and the line $B\ C$ represents to scale the force in the vertical direction $O\ X$. We find $A\ C =$ 1 inch = 1 pound and $B\ C =$ 1.732 inches = 1.732. So we see that the force of 2 pounds, acting at 60 degrees, produces a force of 1 pound in the direction $O\ N$, and a force of 1.732 pounds in the direction $O\ X$.

Those readers who wish to prove this for themselves may do so by making an experimental model, as shown in Fig. 4,

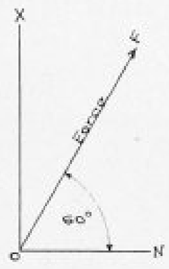


Fig 2

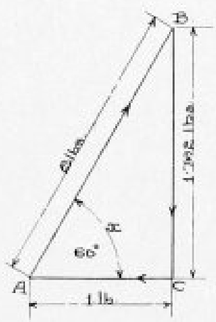


Fig 3

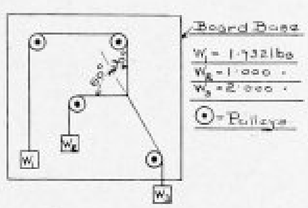


Fig 4

and which does not require further explanation. After a little thought it will be evident that

$$A\ C = \text{force } O\ F \times \text{cosine } x. \qquad (3)$$
$$= 2 \text{ pounds} \times .500 = 1 \text{ pound,}$$

and

$$B\ C = \text{force } O\ F \times \text{sine } x. \qquad (4)$$
$$= 2 \text{ pounds} \times .866 = 1.732 \text{ pounds.}$$

It is therefore obvious that if we know the force and the angle to the horizontal we can find the resultant forces without drawing a diagram, by simply using the formulas (3) and (4). Readers will now, perhaps, see some sort of relation between the radial forces acting at various angles and the resultant stress which will be produced on the material at $A\ A$ or $B\ B$, Fig. 1.

Let us, for an example, and also to make clear the meaning of the previous statements, consider the semi-circle of Fig. 5. Suppose we divide the angles between 30 degrees and 60 degrees into fifteen equal parts, as seen in the figure, we shall have divisions 2 degrees wide. Also let us assume a length of 12 inches, and that the force acts in the center of each strip so as to get a *mean point of application for the face*, or, in other words, the force acting on the area, say between 30 degrees and 32 degrees, is assumed to act at an angle of 31 degrees. The pressure on each area 2 degrees wide and 12 inches long is

$$\frac{\pi \times D \times l \times P}{180} \qquad (5)$$

or in this case it is

$$\frac{3.1416 \times 192 \times 12 \times 200}{180} = 8{,}042.496 \text{ pounds,}$$

or 3.5904 tons.

Calculating as follows:

Mean Angle at which force acts.	Sine of angle × force = Resultant stress at AA.		Cosine of angle × force = Resultant force at BB.	
31°	.51504 × 3.5904 = 1.849	Tons.	.85717 × 3.5904 = 3.078	Tons
33°	.54464 × 3.5904 = 1.954	"	.83867 × 3.5904 = 3.008	"
35°	.57358 × 3.5904 = 2.058	"	.81915 × 3.5904 = 2.940	"
37°	.60182 × 3.5904 = 2.160	"	.79864 × 3.5904 = 2.864	"
39°	.62932 × 3.5904 = 2.258	"	.77715 × 3.5904 = 2.790	"
41°	.65606 × 3.5904 = 2.357	"	.75471 × 3.5904 = 2.706	"
43°	.68200 × 3.5904 = 2.448	"	.73135 × 3.5904 = 2.625	"
45°	.70711 × 3.5904 = 2.538	"	.70711 × 3.5904 = 2.538	"
47°	.73135 × 3.5904 = 2.625	"	.68200 × 3.5904 = 2.448	"
49°	.75471 × 3.5904 = 2.706	"	.65606 × 3.5904 = 2.357	"
51°	.77715 × 3.5904 = 2.790	"	.62932 × 3.5904 = 2.258	"
53°	.79864 × 3.5904 = 2.864	"	.60182 × 3.5904 = 2.160	"
55°	.81915 × 3.5904 = 2.940	"	.57358 × 3.5904 = 2.058	"
57°	.83867 × 3.5904 = 3.008	"	.54464 × 3.5904 = 1.954	"
59°	.85719 × 3.5904 = 3.078	"	.51504 × 3.5904 = 1.849	"
Resultant at AA due to the forces..................	37.633	"	and at BB =.... 37.633	"

So that above radial forces acting on the circumference produces a stress of 37.633 tons at $A\ A$ and a force of the same amount at $B\ B$. Then, evidently, the total stress at $A\ A$ will

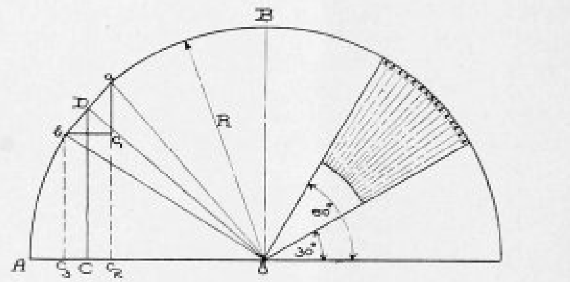


Fig 5

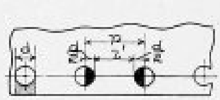


Fig 6

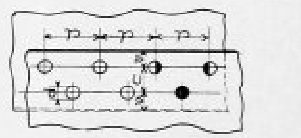


Fig 8

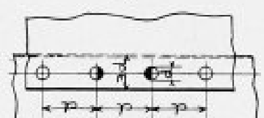


Fig 7

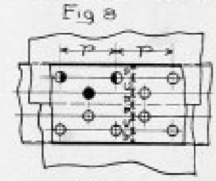


Fig 8

be equal to the sum of sines from 0 to 180 degrees times the pressure as given in formula (5), and the total resultant stress at $B\ B$ equals the sum of cosines from 0 to 180 degrees times the pressure given in formula (5). To find the sum of the sines or cosines for 180 degrees proceed as follows:

Referring to the left-hand side of Fig. 5 the arc $a\ b$ is assumed to be *so small that it is not distinguishable from a straight line* by dividing the arc $A\ B$ into a very great number of equal parts. (Let N = the number of equal parts.) Then the length of each of these minute arcs will be $\frac{\pi R}{2N} = a\ b$.

The line $D\ C$ represents the mean value of the sines of $a\ o\ c_2$ and $b\ o\ c_3$. Therefore, if we take the mean sine for every small arc $a\ b$, and add them together, we shall obtain the sum for 90 degrees, and multiplying by two gives us the sum of sines for 180 degrees.

Since $a\ b$ is at right angles to $O\ D$, $a\ c_1$ at right angles to $O\ A$, and $b\ c_1$ at right angles to $O\ B$, then the angle $b\ a\ c_1$ equals the angle $D\ O\ C$. Therefore

$$\text{sine } D\ O\ C = \frac{D\ C}{O\ D} = \frac{b\ c_1}{a\ b} = \frac{c_2\ c_3}{a\ b},$$

which also follows for other divisions. As $a\,b$ will be the same for every division of the arc $A\,B$, there will be a fraction for every position of $O\,D$, with $a\,b$ for the denominator. The sum of these fractions for the quadrant $A\,B$ is

$$\frac{c_2 c_3 + c_4 c_5 + c_6 c_7 + \text{etc.}}{a\,b}.$$

The sum of the numerators for the whole quadrant is $O\,A = R$; therefore sum of sines $= \frac{R}{a\,b}$, and since $a\,b = \frac{\pi R}{2N}$ the sum of sines must be equal to

$$\frac{R}{\frac{\pi R}{2N}} = \frac{2N}{\pi} \text{ for } 90^\circ,$$

and for

$$180^\circ = \frac{4N}{\pi} \qquad (6)$$

As in formula (5) we considered forces acting at 2 degrees $N = 45$ for the quarter-circle, therefore (6) becomes

$$\frac{4 \times 45}{3.1416} = 57.2958.$$

Combining formula (5) with (6) we get

$$\frac{\pi \times D \times l \times P}{180} \times \frac{4N}{\pi}$$

$$= \frac{3.1416 \times D \times l \times P \times 57.2958}{180} = D \times l \times P,$$

which will be recognized as formula (1), and is equal to the stress at $A\,A$ or $B\,B$, since the sum of the sines or cosines for 180 degrees is the same.

To resist the above stress $D\,L\,P$ we have two thicknesses of plate, one on each side, of the thickness t and length l. The area of this equals $2\,t\,l$ square inches. Combining with the last formula

$$2\,t\,l\,f_t = D\,l\,P, \text{ or}$$

$$f_t = \frac{D\,l\,P}{2\,t\,l} = \frac{D\,P}{2\,t}. \qquad (7)$$

Transposing

$$t = \frac{D\,P}{2\,f_t}.$$

To make an allowance for a factor of safety we have to make t, F_s times thicker than the above formula would allow, so we get

$$t = \frac{D \times P \times F_s}{2 \times f_t}. \qquad (8)$$

Which we know to be the usual formula for a cylindrical shell without a joint. Working out our example

$$t = \frac{192 \times 200 \times 4.5}{2 \times 62{,}720} = 1.373 \text{ inches.}$$

When we put a riveted joint into a cylindrical shell such as we are considering, we have, obviously, to drill holes through the shell for the rivets, as in Fig. 6, thus taking away a certain amount of the area $2\,t\,l$. We thus increase the stress per square inch on the material which is left. Now this stress has not to be above a certain limit, so that we shall have to thicken up the metal in between the holes so as to bring the area of metal up to its original value, or equal to $2\,t\,l$ in area.

Evidently we have to again make the shell thicker than would be required to conform with formula (8), the amount depending upon the amount of metal removed by the drill, or, in other words, if we take the distance p of Fig. 6 to equal l, the area of metal is $t\,p$ or $t\,l$, and if we remove, say, .42 of $t\,p$ we have an area of metal left which is equal to $t\,p - t\,d = p - d$. Calling $p\,t$ equal to 1.00, $t\,l' = 1.00 - .42 = .58$ area of metal left. This expressed as a percentage

$$= \frac{100\,(p - d)}{p} = n. \qquad (9)$$

$$n = \frac{100\,(1.00 - .42)}{1.00} = 58 \text{ percent,}$$

which we call the plate efficiency of the joint. We shall therefore have to make the shell $\frac{1}{n}$ times thicker than found by formula (8). Then for a shell with a riveted joint we get

$$t = \frac{P\,D\,F_s \times 1}{2\,f_t\,n} = \frac{P\,D\,F_s}{2\,f_t\,n}. \qquad (10)$$

Where n = percent efficiency of the riveted joint,
let f_s = shear strength of rivets in pounds per square inch = 51,520,
p = pitch of rivets in inches,
d = diameter of rivet holes,
f_c = crushing strength of plate pounds per square inch = 103,040 pounds,
N = number of rivets in one pitch p,
S = percentage of shear strength of rivets in one pitch p to strength of plate of t thickness and p length, or

$$S = \frac{100 \times .7854\,d^2 f_s N}{p\,t\,f_t}. \qquad (11)$$

Considering a shell of length l equal to p, the resistance of this to tearing in between the rivets is $(p - d)\;t\,f_t$, and the resistance to shearing of the rivets is equal to $.7854\,d^2\,f_s\,N$ where $.7854\,d^2$ equals sectional area of one rivet. The resistance to the crushing of the metal shown shaded in Fig. 6 is equal to $d\,t\,f_c$. If the resistance to tearing is equal to the resistance to shearing, then $(p - d)\;t\,f_t = .7854\,d^2\,f_s\,N$, and for Figs. 7 and 8

$$p = \frac{.7854\,d^2 f_s\,N}{t\,f_t} + d = \frac{.646\,d^2\,N}{t} + d \qquad (12)$$

where $N = 1$ for Fig. 7 and $N = 2$ for Fig. 8. Also, if the resistance to shearing is equal to crushing then $.7854\,d^2\,f_s = 2\,t\,f_c$, and

$$d = \frac{t\,f_c}{.7854\,f_s} = 2.54\;t.$$

The crushing resistance need not, therefore, be considered when d is less than 2.54 t for rivets in single shear.

The following gives good proportions for t and d:

Thickness of plates..........	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"
Diameter of rivet hole......	11/16"	3/4"	13/16"	7/8"	15/16"	1"	1 1/16"
Thickness of plates..........	3/4"	13/16"	7/8"	15/16"	1"	1 1/4"	1 1/2"
Diameter of rivet hole......	1 1/8"	1 3/16"	1 1/4"	1 5/16"	1 3/8"	1 7/16"	1 1/2"

It will be seen that d is in every case less than 2.54 t, so that the crushing of rivets in single shear need not be considered if the above proportions are adopted. For Fig. 8

$$C = \frac{\sqrt{16\,d^2 - p^2}}{2},$$

Fig 9 shows a double-riveted butt joint in which the rivets are in double shear. It has been proved that a rivet in double shear is twice as strong as a rivet in single shear, although the Board of Trade only allow 1.875 times that of a rivet in single shear. We will use the Board of Trade rule on the following formulas:

The formula for crushing now becomes

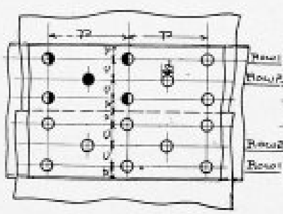
$$d = \frac{t f_c}{1.875 \times .7854 f_s} = 1.355\, t,$$

so that the resistance to crushing need only be considered with rivets in double shear when d is less than $1.355\, t$. The formulas for the joint shown in Fig. 9 are:

$$p = \frac{1.875 \times .7854\, d^2 f_s N}{t f_t} + d = \frac{2.4216\, d^2}{t} + d. \quad (13)$$

$$C = \frac{\sqrt{(11 p + 4 d)\ (p + 4 d)}}{10}.$$

Theoretically the butt straps need only be of thickness t_1 equal to $.5t$. But the Board of Trade require $.625\, t$, which is



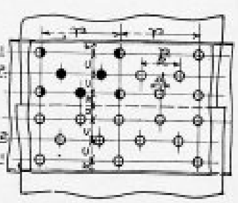
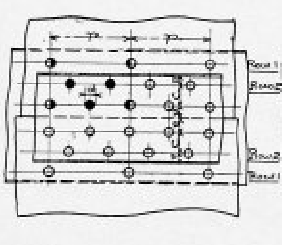


Fig. 10 Fig. 11

Note: v in every case equals 1.5 d.



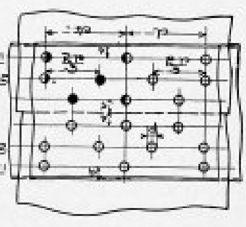


Fig. 12 Fig. 13

certainly better for calking tight than the thinner plate, especially when the pitch is large. The plate percentage formula is still $\frac{100\,(p - d)}{p} = n$. But, as will be seen, n has a higher value, due to the pitch being greater.

$$S = \frac{100 \times 1.875 \times .7854\, d^2 f_s \times 2}{p\, t\, f_t} = \frac{242.16\, d^2}{p\, t} \quad (14)$$

Fig. 10 shows a treble-riveted butt joint with inside and outside straps of equal width. The formulas for this joint are:

$$p = \frac{1.875 \times .7854\, d^2 f_s \times 3}{t f_t} + d = \frac{3.6324\, d^2}{t} + d. \quad (15)$$

$$C = \frac{\sqrt{(11 p + 4 d)\ (p + 4 d)}}{10},$$

and

$$S = \frac{363.24\, d^2}{p\, t} \quad (16)$$

$$t_1 = .625\, t.$$

And since the tearing of the plate is always on the outside row center line we get for this and all other cases:

$$n = \frac{100\,(p - d)}{p}.$$

If, now, in a treble-riveted butt joint we leave out every alternate rivet in the outer row, as seen in Fig. 11, we get a still more efficient joint, since the pitch p is twice as great as that of Fig. 10, and yet we have only one rivet diameter to take from the pitch, which will obviously give us a still greater value of

$$n = \frac{100\,(p - d)}{p}.$$

Assuming the inner and outer straps to be of equal width, the formulas for Fig. 11 are:

$$p = \frac{1.875 \times .7854\, d^2 f_s \times 5}{t f_t} + d = \frac{6.054\, d^2}{t} + d \quad (17)$$

$$C = \frac{\sqrt{(11 p + 8 d)\ (p + 8 d)}}{20}$$

$$t_1 = \frac{5\, t\,(p - d)}{8\,(p - 2 d)}$$

$$S = \frac{1.875 \times .7854\, d^2 f_s\, 5}{p\, t\, f_t} = \frac{605.4\, d^2}{p\, t} \quad (18)$$

This joint might give way by the shearing of the rivets in the outer row and the tearing of the plate in between the rivets of the inner row. Then the percentage strength of joint is equal to

$$S_1 = \frac{100\,[1.875 \times .7854\, d^2 f_s + (p - 2 d)\, t f_t]}{p\, t\, f_t}$$

$$S_1 = \frac{121.08\, d^2 + 100\,[(p - 2 d)\, t]}{p\, t} \quad (19)$$

If one strap is narrower than the other, as is often the case, and as shown in Fig. 12, the formulas are:

$$p = \frac{1.875 \times .7854\, d^2 f_s \times 4 + .7854\, d^2 f_s}{t f_t} + d = \frac{5.488\, d^2}{t} + d \quad (20)$$

$$S = \frac{548.8\, d^2}{p\, t} \quad (21)$$

$$S_1 = \frac{100\,[.7854\, d^2 f_s + (p - 2 d)\, t f_t]}{p\, t\, f_t}$$

$$S_1 = \frac{64.56\, d^2 + 100\,[(p - 2 d)\, t]}{p\, t} \quad (22)$$

When making the preliminary calculations it is usual to assume a value for the efficiency of the joint, and after having definitely settled the pitch and thickness to accurately work out the percentages to the formulas given above. The following are suitable values to assume:

For Fig. 7 = 55 percent. For Fig. 8 = 68 percent.
Fig. 9 = 75 percent. Fig. 10 = 82 percent.
Fig. 11 = 85 percent.

For such a large diameter of shell as we have taken for an example we should use the joint shown in Fig. 11, which, as given above, has an efficiency of about 85 percent.

After correcting for the joint the shell thickness t is for our example:

$$t = \frac{1.373}{.85} = 1.619, \text{ say } 1\tfrac{5}{8} \text{ inches.}$$

For this thickness $1\frac{5}{8}$-inch diameter rivets should be used. And

$$p = \frac{6.054 \times 1.625 \times 1.625}{1.625} + 1.625 = 11.475 \text{ inches.}$$

$$n = \frac{100\,(11.475 - 1.625)}{11.475} = 86 \text{ percent.}$$

$$S = \frac{605.4 \times 1.625 \times 1.625}{11.475 \times 1.625} = 86 \text{ percent.}$$

For such a joint as Fig. 11 the stress on the plate between the second row of rivets is greater than the stress on the plate between the rivets of the first row. For Fig. 11 the stress on the joint for one pitch p is

$$f = \frac{p\,P\,D}{2} = \text{pull between one pitch.}$$

The length of plate between the rivets in row 1 is $(p - d) = l_1$, and the tensile stress in pounds per square inch on the plate between these rivets is $f_t = \dfrac{f}{l_1 \times t}$, and the shearing of rivets in pounds per square inch is

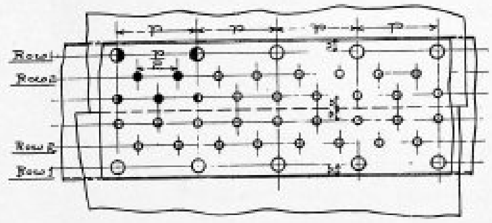
$$f_s = \frac{f}{5 \times 1.875 \times .7854\, d^2}.$$

And the total stress taken by the rivet in the outer row $= f_s \times 1.875$.

The pull along the plate in row 2 $= f^2_t = f - (1.875 \times .7854\, d^2 f_s)$. The $1.875 \times .7854\, d^2 f_s$ is evidently the stress which is transmitted through the rivet in row 1 to the butt straps.

And the length of plate in between the rivets of the second row $= l^2 = p - 2\,d$; also the tensile stress in the second row is $f^2_t = \dfrac{f^2_t}{l^2 \times t}$. Which will be found to come to more than the stress in row 1. For instance, taking the case of our example, stress on plate in between rivets of row 1 = 13,750 pounds per square inch; stress on plate in between rivets of row 2 = 14,875 pounds per square inch. There are two methods by which we can overcome this difficulty and make the stresses about equal:

First (referring to Fig. 13), by making the pitch of rivets in row 2 equal to $\dfrac{p \times 2}{3}$, and keep the pitch of rivets in row 1 as before; we thus have only 1.5 d in place of 2 d to take from the pitch p, thereby increasing the sectional area of plate in between rivets and reducing the stress per square inch due to the increased area. Secondly (referring to Fig. 14), by making the rivets larger in row 1 and keeping the pitch of rivets in row 2 the same as in Fig. 11, which, on the whole, is the best method of the two. It will then be found possible to make the stress per square inch of metal in row 1 practically the same as that in row 2. Of course, if the above methods are adopted then the formulas for the pitch, etc., of the joint would have to be modified to suit. As space does not permit of comparing the joints of Figs. 13 and 14, taking the above into consideration, it will be left for readers sufficiently interested to do so for themselves, simply remarking, in conclusion, that



v = 1.5 d.

Fig. 14.

it will be of much interest and value for them to do so, they will then see which really is the most efficient joint of the two, taking practically all things into consideration.

Personal Notes

WALTER GERNER has been appointed by the Hartford Steam Boiler Inspection & Insurance Company chief inspector at its Cincinnati office.

WILLIAM A. CRAIG has been appointed assistant chief inspector at the Pittsburg office of the Hartford Steam Boiler Inspection & Insurance Company.

ALEXANDER RITCHIE has been appointed superintendent of the boiler department of the Canada Foundry Company, Toronto, Can., to succeed Mr. John Weise.

JOHN WEISE, formerly superintendent of the boiler department of the Canada Foundry Company, Toronto, Can., has resigned to take a similar position with the Gem City Boiler Works, Dayton, Ohio.

D. A. STARK has been appointed foreman boiler maker at the Kingsville (Texas) shops of the St. Louis, Brownsville & Mexico Railway Company, in place of L. Arnold, who has resigned to accept other duties.

ALLEN D. RISTEEN, Ph. D., for the last twenty-three years in the service of the Hartford Steam Boiler Inspection & Insurance Company as assistant editor and editor of *The Locomotive*, has resigned to take up special literary work, including the preparation of a new encyclopedia covering in condensed form the fields of history, literature and science.

E. W. ROGERS, general foreman boiler maker of the Rogers Works of the American Locomotive Company at Paterson, N. J., was transferred, Feb. 1, to the Schenectady plant of the American Locomotive Company, succeeding Mr. F. G. Bird, formerly general foreman of the Schenectady boiler shop. Mr. Bird has been appointed general foreman of all the plants of the American Locomotive Company.

CHARLES H. GARLICK, past president of the National Association of Stationary Engineers and prominently identified in industrial enterprises in Western Pennsylvania, on Feb. 2 was appointed inspector of steam engines and steam boilers for Allegheny Countyby Governor John K. Tener. He succeeds J. J. Kelly, who has held the position about four years. The compensation is figured on the fee basis.

Following evidence given at the coroner's inquest and the investigation by the United States Inspectors of Steam Vessels into the explosion of the boilers on the towboat *Diamond* in the Ohio River near Pittsburg, Dec. 3, Chief Engineer Charles Martin and Second Engineer Frank Price of the boat's crew were suspended for a period of six months. Five men lost their lives in the explosion.

Electric Welding Applied to Boiler Work in Railway Shops*

BY O. S. BEYER, JR.

A process of autogenous welding by electricity, patented and known as the Siemund Wenzel process, has recently been applied in several railway repair shops. For several years it has been used in steamship, boiler and machinery repairs, and its success in marine repair work naturally suggested its use on railways. To-day, but eight months from the time a complete welding outfit was first installed in the Hornell shops of the Erie Railroad, its success has been so marked that it bids fair to become as standard a railway repair device as pneumatic tools, wheel and crank pin lathes, flue welders, cylinder borers and other tools characteristic of railway shops. The extent to which the process finds successful application is very great. On steamships, where it was first used, such highly stressed parts as boiler and furnace sheets, shafts, stern frames and rudder posts have been repaired. Its use in the railway repair shop is not confined to locomotive boilers and fireboxes, but is extended to machinery, cylinders, wheels and even to driving tires. Defective and worn parts of stationary boilers of both the firetube and watertube types have been repaired. Broken machine tool parts have been reclaimed. Indeed, its application is suggested wherever machinery of any kind is used and maintained.

The illustrations show a few examples of electric welding done at the Hornell shops of the Erie Railroad. Figs. 1 to 4 show the different stages of welding the mud-ring of a standard consolidation locomotive. The mud-ring was broken through at the left front corner. If repaired in the old way it would have been necessary to remove and weld it in the blacksmith shop. The mud-ring was drilled, chipped and welded out to its original size by filling in 74 cubic inches of metal. The work had been partially completed, as shown in Fig. 1, when another defect was discovered, and it became necessary to drill and chip out another section of the ring, as shown in Fig. 2. The finished job is shown in Fig. 3. A view of the finished weld on the inside of the firebox is shown in Fig. 4. In connection with the mud-ring repairs the seams around the right front and left back corners of the mud-ring were welded. A patch under the fire-door opening, Fig. 5, was also welded around its edges in place of calking. The comparative costs for repairing this mud-ring by the old method and the electric welding method are as follows:

Old Method—Stripping engine, removing mud-ring, welding mud-ring, preparing mud-ring for re-application, re-applying removed engine parts, all material and labor complete; labor prices based on prevailing piece work prices...............	$118.06
Electric Welding Process—Preparing, welding, finishing, material, labor and electric current, complete.	32.07

The application of electric welding in firebox repairs is shown in Fig. 6. The longitudinal seams between the side sheets and crown sheet of the firebox were so wasted away by calking that the engine was sent to the shops for a new firebox. The seams were welded their entire length, approximately 6 feet 10 inches, by applying metal averaging 3 inches in width and 3/8 inch in thickness. Had the engine received a new firebox it would have been necessary to strip it and remove the boiler to the boiler shop. The cost of applying a new firebox, as compared to welding the seams by the electric process, is as follows:

Application of New Firebox—Stripping engine, transferring boiler, laying out firebox sheets, building and applying firebox, applying stay-bolts, crown bolts, mud-ring, etc., overhauling flues, riveting and calking, refitting engine; all labor and material complete.........................	$777.18
Welding seams and defects by electric process; all labor, material and electric current complete....	56.40

Another example of electric welding on a locomotive firebox is shown in Figs. 7 to 10. The sheets of this firebox were cracked along the mud-ring, and a patch on one side was so wasted away that it would have been necessary, had the elec-

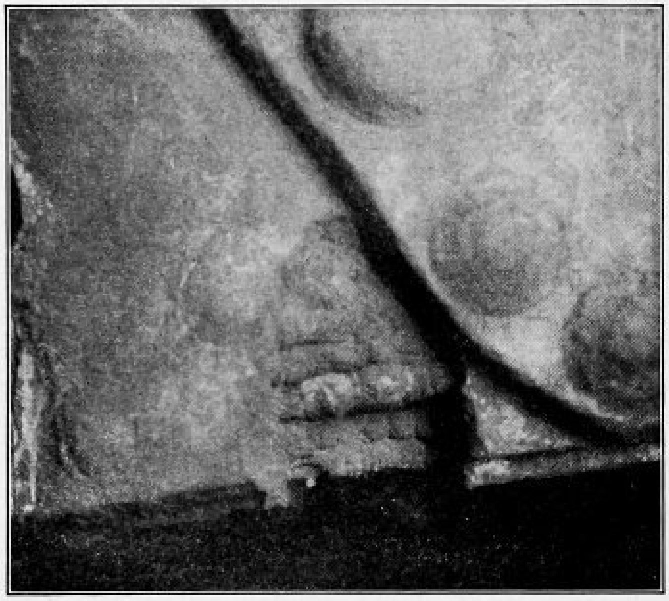


FIG. 1.—MUD RING PARTIALLY WELDED AFTER BEING DRILLED AND CHIPPED OUT

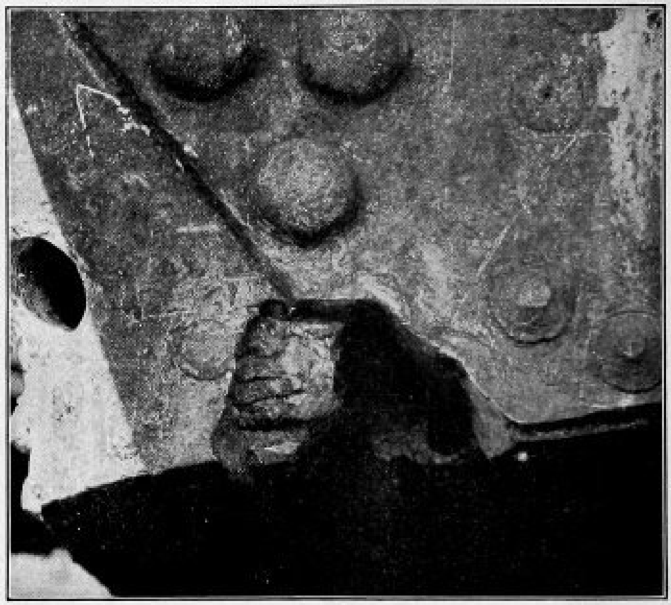


FIG. 2.—IT WAS NECESSARY TO REMOVE MORE OF THE DEFECTIVE MUD RING AFTER BEING PARTIALLY WELDED

* By courtesy *American Engineer*.

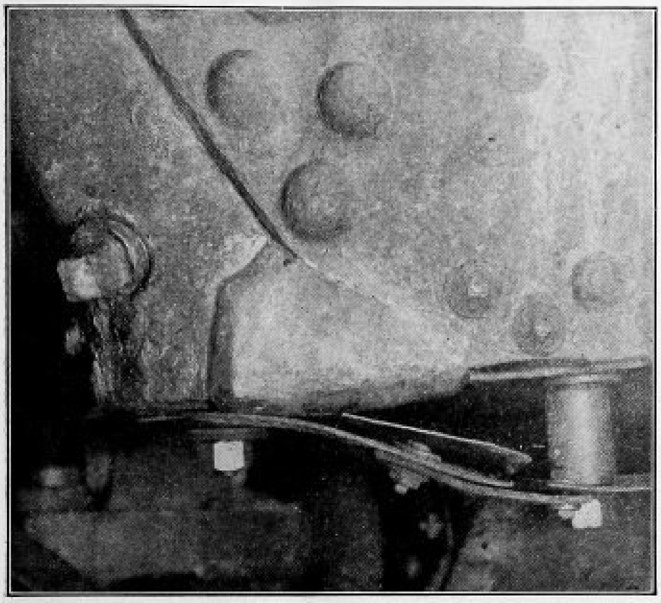


FIG. 3.—THE FINISHED WELD ON THE MUD RING AND SHEET

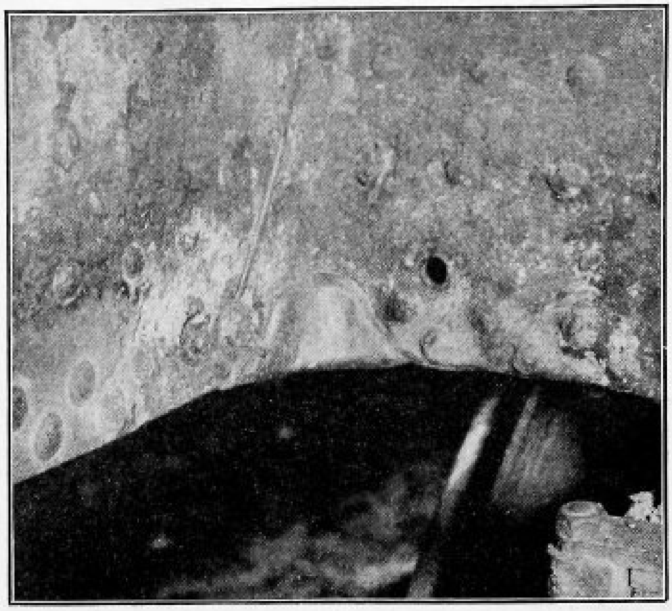


FIG. 4.—SHOWING THE INSIDE OF THE FIRE-BOX WHERE THE MUD RING WAS WELDED

tric welding process not been available, to renew the entire box. Fig. 7 shows the defects in the sheet at the left corner of the firebox. The white line indicates where the sheet would ordinarily have been cut out and a new patch applied. Fig. 8 shows the cracks which were welded near the left front corner of the mud-ring, the rough surface of the weld having been chipped off and finished. The right back corner of the fire-box, after the cracks were properly welded, is shown in Fig. 9. Had it been necessary to renew the entire firebox the cost would have been as follows:

New firebox complete, all work and material........	$800.68
Cost of electric welding which obviated the necessity for a new firebox, including material, current and labor complete	22.11

An interesting example of the welding on of a vertical firebox patch is shown in Fig. 10.

Part of a back flue sheet, three of whose flues were welded to the sheet for purposes of demonstration, is shown in Figs. 11 and 12. Fig. 11 shows the three flues securely welded to the sheet. Fig. 12 shows the flues after welding, chipping and trimming with a pneumatic hammer. Since this experiment has been made, complete sets of flues have been welded to the back flue sheets of several engines, and the engines have been returned to service. Close observation of these engines indicates that the work in the engine house to keep the flues tight is considerably reduced. Three months' service of a few engines is too short to look for ultimate results. The indications, however, are that by the use of electric welding in flue applications, a step in advance in boiler construction and maintenance has been made. Add to this what will be gained by electrically welding all firebox and mud-ring seams, while the boiler is being built, and the proper maintenance of locomotive boilers may be considerably simplified from its present perplexing state.

An electric welder at work on a flue sheet welding the flues and bridges is shown in Fig. 13. The welding clamp is held in one hand while the other holds a frame containing three thicknesses of ruby or green glass through which the operator observes his work. The electric machinery seen in the rear is a temporary installation, being a low-voltage generator, belt-driven by a standard motor, all mounted on an improvised wooden base. A typical installation will be illustrated and described later.

Description of Process

The system is of the arc type. It employs direct current supplied at potentials of 20 to 30 volts at the arc and 50 to 80 volts at the generator terminals. One lead of the welding circuit is attached to the welding clamp which holds the welding material—pencil or electrode. The current is furnished by a generator usually direct connected to a motor, properly wound for the current and line voltage available at the place of installation.

An electric arc of about 3/16 inch to ¼ inch long is sprung between the welding material or pencil and the object to be repaired. The voltage is regulated until the current is of the

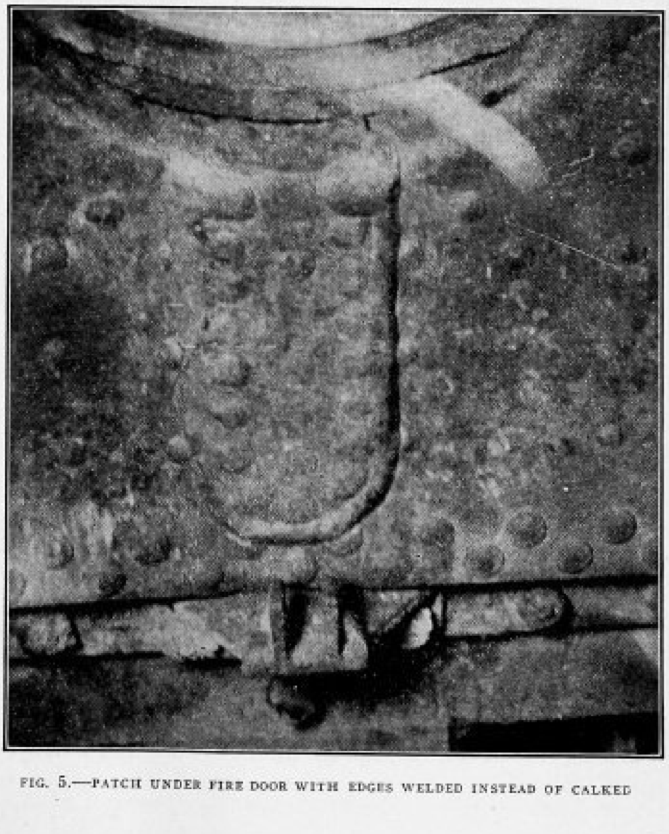


FIG. 5.—PATCH UNDER FIRE DOOR WITH EDGES WELDED INSTEAD OF CALKED

proper amount to suit the work in hand. The spot on the surface of the object being welded, where the electric arc strikes, is instantly brought up to a state of incipient fusion, and minute molten particles of the pencil or electrode detach themselves progressively in a continuous rapid stream, and, following the arc, attach themselves securely at the spot where the arc strikes. This proceeds very uniformly until either the arc is interrupted or a sharp fluctuation in current takes place.

About every minute or so the actual welding operation is stopped while the operator subjects the local heated area of the weld which he is making to rapid blows from a small hand hammer. The object of this is primarily to force out any minute portions of oxide or slag that may have formed, due to the presence of impurities or improper manipulation. It is also done with the object of working the metal of the weld, and to close up any small pin holes that may have formed. The repairing material is applied until the chipped and V'd out portion is entirely filled up, and then an additional amount is applied for reinforcement. This works out very satisfactorily, since the additional material added adheres as securely as the material which is part of the direct weld, and thus serves to reinforce in direct proportion to the section of the material added. Consequently there is no reason why a weld thus reinforced cannot be made as strong, or even stronger, than the original material. In practice it is found desirable to reinforce welds of this nature sufficiently to make their tensile strength about equal to the tensile strength of the original material.

The arc and the molten particles of material are guided by a magnetic flux which originates in the electrode holder. The welding current is led around the handle of the holder through a heavy series coil in such a way that a strong magnetic current is set up which travels through the pencil and in the direction of the arc. The presence of this magnetic current assists greatly in causing a very rapid deposition of the repairing material and makes overhead welding possible and perfectly practical. Without this magnetic current, overhead welding could not be done with any degree of certainty as to the results. The magnetic curent also increases the strength of the weld owing to its concentrating influence and the cooling effect on the arc. It prevents oxidization of the molten particles while in transit and the formation of slag and pin holes that sometimes forms in the weld.

The welding pencil consists of a very pure grade of Swedish iron of a definite cross sectional area. It has been determined by careful laboratory research that the quality of the repairing material and the pencil diameter have a decided influence on the properties of the weld. A definite relation exists between the size of the pencil, the amount of the current, and the tensile strength of the weld. Hence the quality of the material and the size of the pencil must be carefully selected.

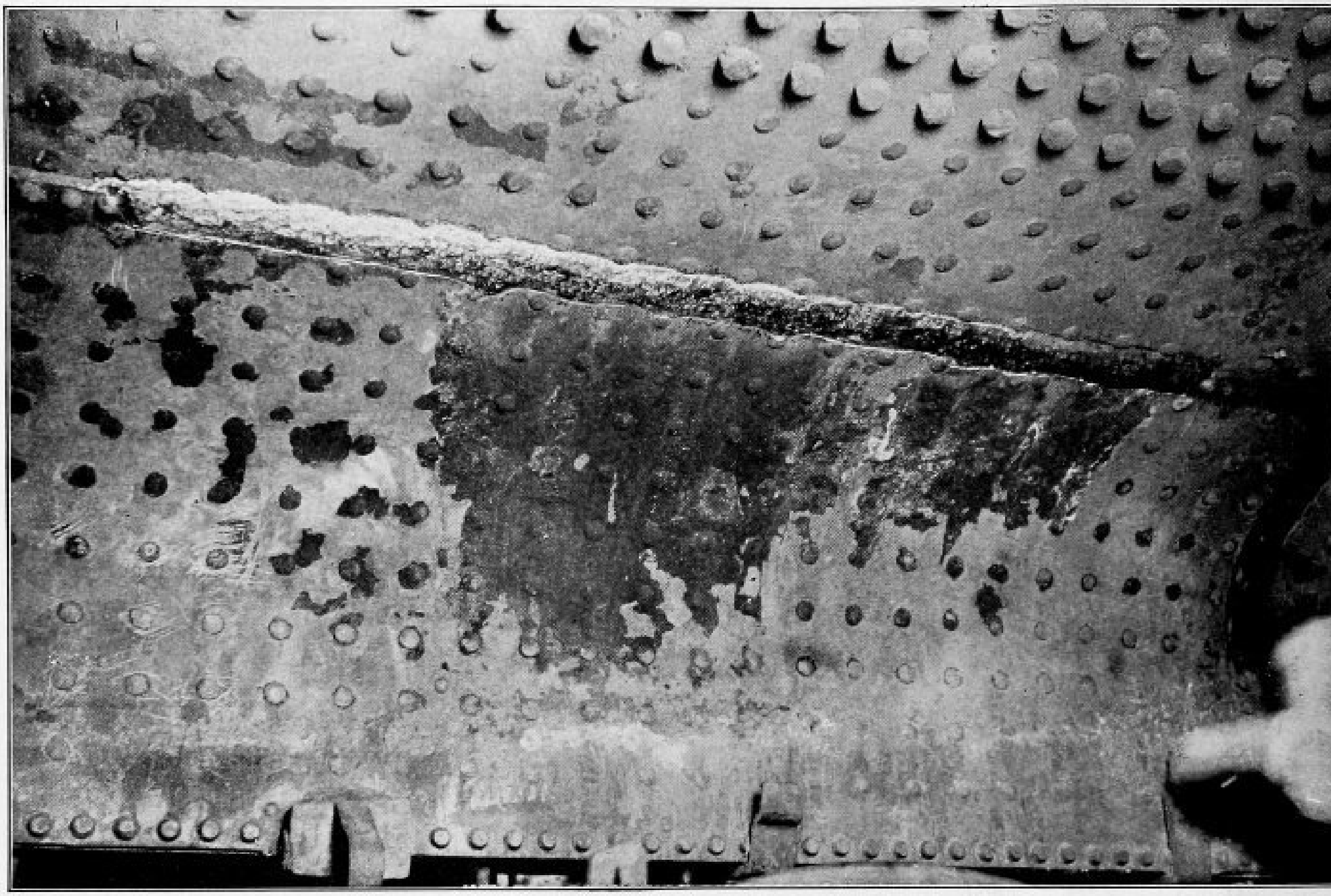


FIG. 6.—A LONGITUDINAL SEAM, OVER 6 FEET LONG, REPAIRED BY ELECTRIC WELDING

In order to prevent oxidation and the consequent formation of slag, and also to provide certain ingredients which affect the welding material chemically and so benefit it physically by making it soft and ductile, the welding pencil or electrode is covered with a flux. When the welding operation is carried on the flux melts and vaporizes, enclosing the molten particles and the arc to the exclusion of atmospheric oxygen, which attacks the repairing material in its fused state, and thus improves the quality of the weld.

Description of Apparatus

An electric welding installation consisting of a motor generator set, the necessary control apparatus, measuring instruments and protective and steadying resistances, is shown in

Fig. 14. This outfit is in use in a railway shop. The motor generator is provided to convert the standard current available into direct current at voltages suitable for welding. Hence the motor may be either of the direct or the alternating-

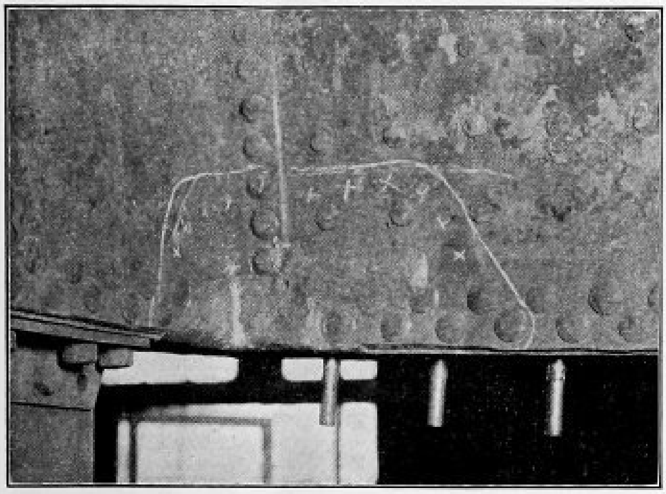


FIG. 7.—DEFECTIVE FIRE-BOX SHEETS REPAIRED BY ELECTRIC WELDING

current type. The generator is wound to furnish a maximum constant output of 200 amperes direct current at a range in potential of 50 to 80 volts. This range in voltage is secured by varying a resistance in series with the field circuit. A variable rheostat for this purpose is mounted on the slate switchboard so that it may be conveniently manipulated by the operator.

A second resistance is placed in one leg of the welding circuit, in such a position that when the generator is short circuited at the instant of striking the arc the resistance acts as a protection to the armature and commutator of the generator by limiting the maximum current possible at a maximum voltage to the greatest permissible instantaneous overload capacity of the generator. Another resistance is provided which is automatically thrown in series with the above resistance and across the terminals of the generator the instant the welding arc is interrupted. Together these two re-

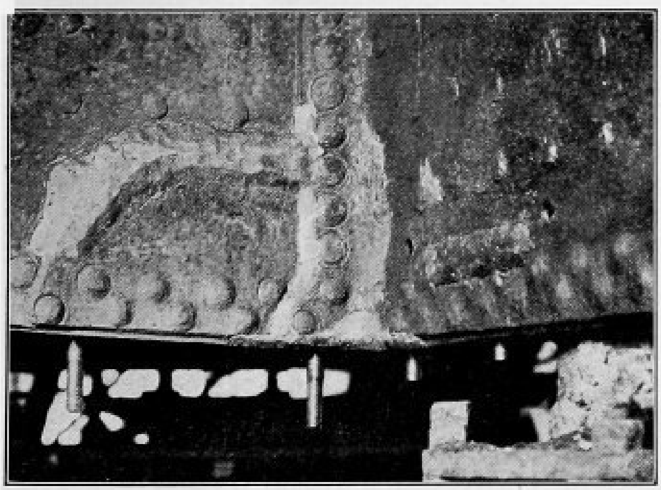


FIG. 9.—ELECTRICALLY WELDED CRACK IN CORNER OF FIRE-BOX

sistances serve as a secondary or temporary load on the generator when the welding operation has ceased. The instant the welding is started again, this latter resistance is automatically cut out. These two resistances are so proportioned that the load which they impose upon the generator equals the load imposed upon the generator when the welding operation is under way. In this way violent fluctuations of the load on the motor generator are avoided. Furthermore, this particular arrangement results in the best welding work. The closer the regulation and the more constant the generator voltage the less the likelihood of pin holes and defects in the weld.

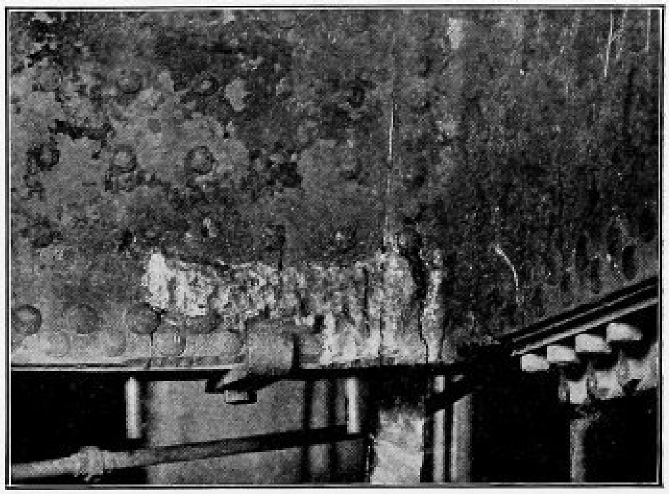


FIG. 8.—REPAIRS TO FIRE-BOX SHEETS MADE BY ELECTRIC WELDING

An ammeter and a voltmeter, which are both connected to the welding circuit, are mounted on the switchboard. These instruments serve the purpose of indicating the amount of current and the voltage of the welding circuit. The welding clamp or holder consists of a wrought iron handle, properly insulated, around which is wound a coil. This coil, in turn, is

FIG. 10.—SIDE SHEET PATCH WELDED TO FIRE-BOX

insulated from the hand by a leather covering. To one end of the coil is attached one of the leads of the welding circuit; the other end of the coil is attached to the holder near the base of the clamp. The clamp consists of a projection from the holder and a piece of spring steel, so fastened together that the combination serves to hold the welding pencil or electrode rigidly. The entire welding outfit, except the holder and weld-

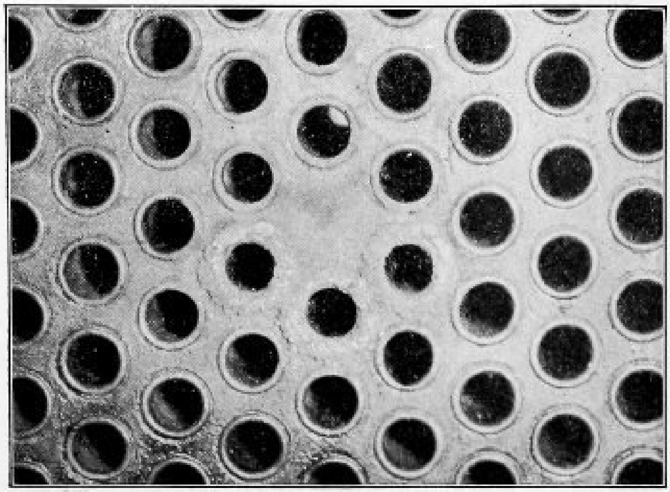


FIG. 11.—THREE TUBES WELDED IN FLUE SHEET

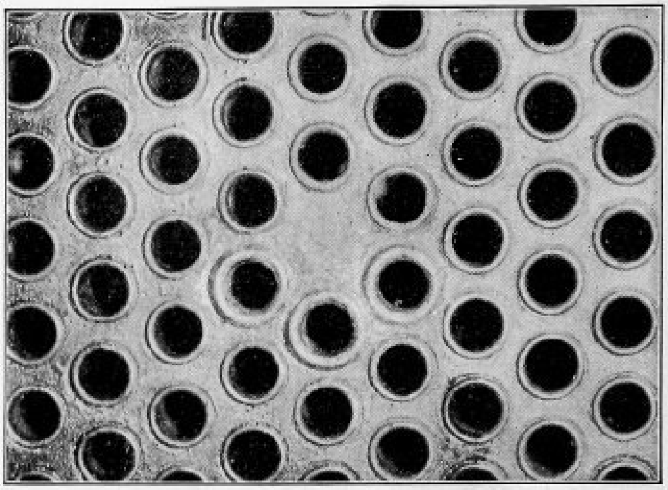


FIG. 12.—WELDED TUBES AFTER BEING CHIPPED AND TRIMMED

ing leads, is mounted on a substantial base, which in the case of the illustration is made up of standard rolled steel sections. For the machines now being built this base is of cast iron with suitable projections on the back, to which are fastened the banks of resistance which are part of the installation. The slate switchboard, with its terminal lugs, fuses, switches, motor-starting box, electrical measuring instruments, contactors and relay, is mounted on an angle-iron frame securely fastened to the bed of the motor generator set and the machine housings. In this way a firm and compact arrangement is secured.

An electric welding installation, such as described above, is capable of furnishing sufficient electricity for one welder at a time. The welding lines are brought from the switchboard to any place desired in the shop. In fact, a main, or several main welding circuits may be installed throughout the shops, with

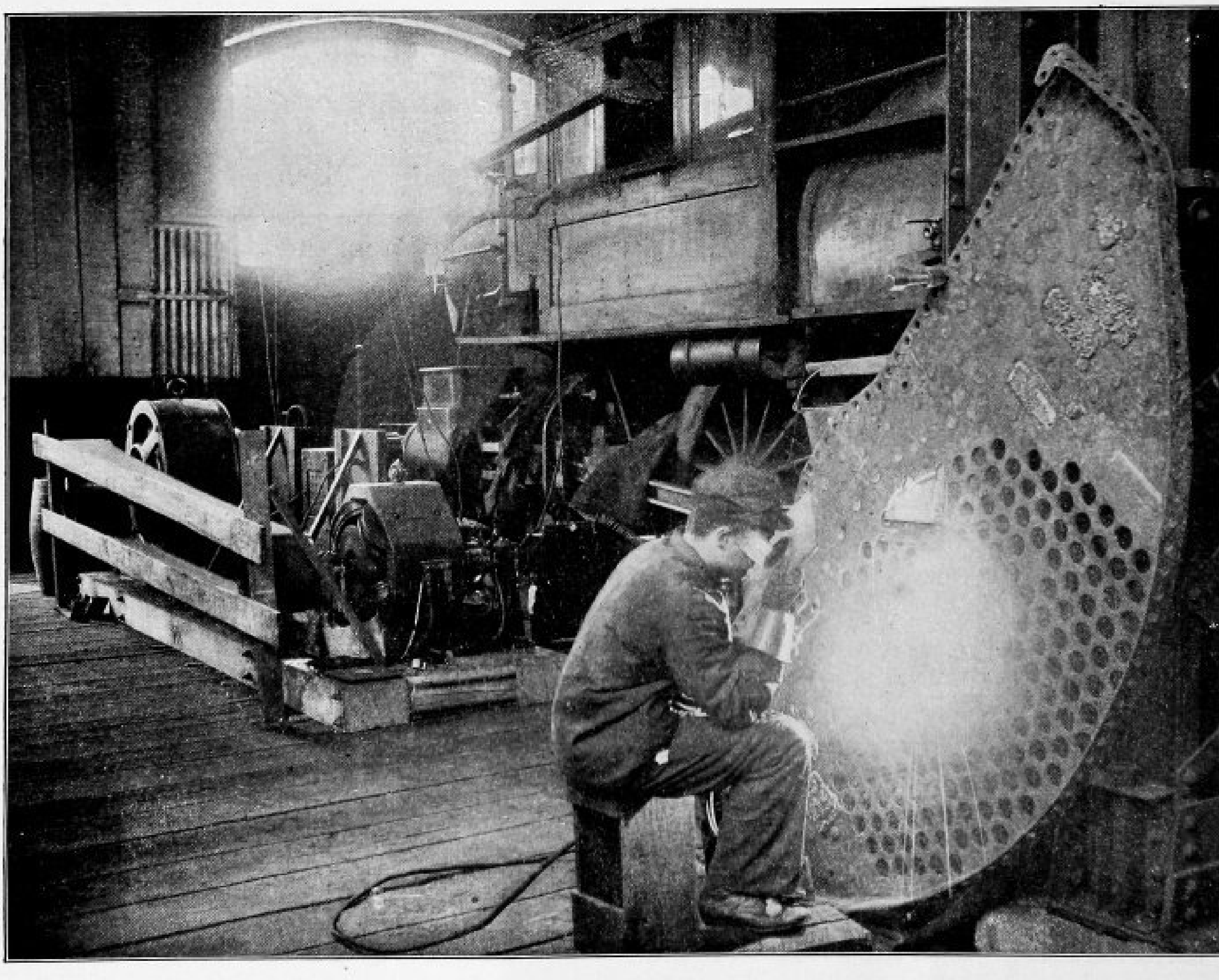


FIG. 13.—ELECTRIC WELDER AT WORK; ELECTRIC MACHINERY IN THE REAR IS A TEMPORARY INSTALLATION

occasional taps so arranged that it is only necessary to attach limited lengths of flexible welding cables to the main circuit at the taps and run these to the places where the welding work is to be done.

ADVANTAGES OF ELECTRIC WELDING

From the foregoing it is obvious that autogenous welding by electricity has many advantages. The simplicity of the process at first sight is its most striking feature. The art of electric welding is not difficult to learn. Welders who can turn out work with uniform success can be made in three to four weeks. The hardest thing to acquire is the ability to maintain the arc steady and keep feeding the electrode uniformly. When once this is learned, together with the way to adjust the appartaus, the welds secured will be successful.

Another feature which is greatly to the advantage of the electric welding process is the entire absence of danger from explosion and fire. There is nothing whatever to explode, and the low potential of the welding circuit, together with the protective resistances and the fuses in the welding circuit leads, reduce the fire dangers from faulty insulation or short circuiting to nothing. The fact that the voltage is so low makes this process absolutely safe to handle by the welder, considered from all viewpoints.

The wide range of application of the process is another one of its distinct advantages. It may be used to do very heavy as well as light work. Its success in this direction has been proved more by its extending application in the repair of heavy machine parts and the framing of ships than by its application to locomotive repairs. To date it has hardly been sufficiently extended in locomotive repair work to demonstrate the limits of its possibilities. However, if highly stressed parts of ships can be repaired by this method there certainly is no reason why the same thing will not hold true in locomotive repairs. New work is being done daily which it had never been considered possible to do, and success is invariably the result.

By the use of the electric welding process it is possible to deposit an additional amount of metal on the part being welded so that it will act as a reinforcement to the weld proper.

As pointed out in the description of the process, the electric arc is narrowly confined, and only heats a very limited area on the surface of the object being repaired to incipient fusion. This heating is instantaneous, taking place immediately when the arc is struck. Thus the heat incidental to the welding operations, though intense, is extremely localized, being just sufficient to fuse a small spot to which the molten particles from the welding pencil attach themselves. It is not necessary to preheat a large surrounding portion so that a sufficient amount of heat is stored up in the adjacent material. Owing to this very marked characteristic—the extreme localization of the heat—no cooling strains are set up around the weld after the work is done. Hence there are no subsequent failures from cracking or buckling at the weld or in other parts of the object repaired. It is due to this particular feature that the success of this process, wherever applied, has been so uniform.

The character of the weld itself, it being soft, ductile and free from slag and oxides, as well as injurious carbon compounds of iron, makes the electric weld secured by the Siemund Wenzel process the most perfect secured by any system of autogenous welding. The close regulation of the current guards against injuring the original material adjacent to the weld. This, too, benefits the weld as a whole. The convenience with which overhead welding may be done is another decided advantage. The magnetic current created in the welding holder makes this possible. Overhead welds are made just as fast as welds in any other position and are equally as strong.

Owing to the comparatively small amount of power required, the simplicity of the entire installation, the fact that the machinery used is practically of standard design and manufacture throughout, embodying no untried features of construction, the rapidity with which the work is done and the absolute uniformity of the success of the work, as well as the wide range of its application, make this process the cheapest and best with which to do autogenous welding. The results secured certainly justify this conclusion.

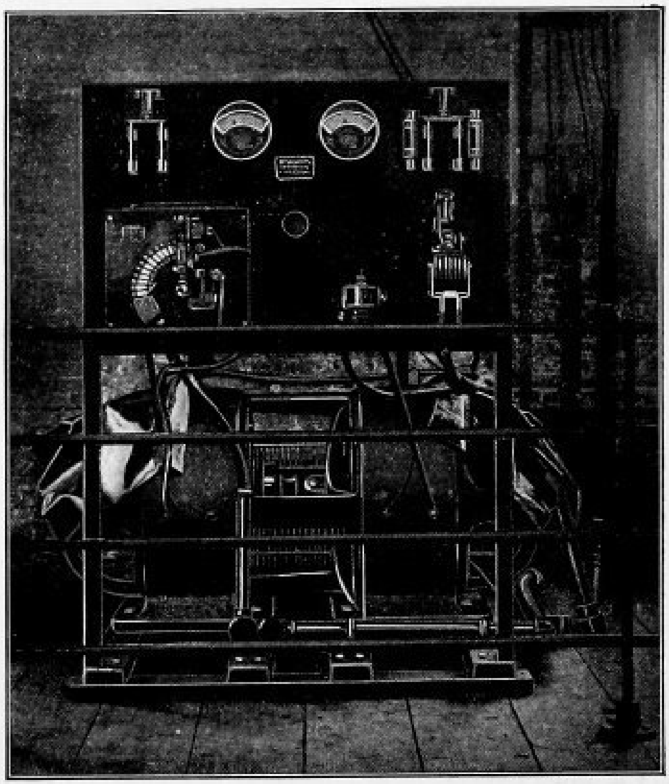


FIG. 14.—A TYPICAL ELECTRIC WELDING INSTALLATION

The boiler on a Delaware & Hudson freight locomotive exploded Dec. 8, 1911, near Westport, N. Y. The fireman was killed and the engineer and head brakeman of the train badly injured. There was an estimated property damage of $7,000. The boiler was a Culm burner of the Wooten type, which had been regularly inspected and the reports approved. The explosion occurred through the failure of the crown sheet, which, in the estimation of the District Federal Inspector, was due to overheating on account of low water. That a certain portion of the sheet had been overheated was indicated by its blue color. There was a very distinct line of demarcation between that and the unheated portions. The blued section extended the full length of the firebox and a distance of 56 inches crosswise. The crown sheet showed evidence of a preliminary yielding prior to the actual explosion, in that it was tufted down between the stay-bolts. The fractured parts of the sheets showed no indications of a preliminary fracture having existed. Fifteen rows of radial stay-bolts were blued at the ends, and the crown sheet, which is 3/8 inch thick, was reduced to 1/8 inch thickness in the center when it tore apart. Holes in the crown sheet elongated 1 5/8 inches by 1 1/4 inches. The firebox sheets, and also the outside throat and casing sheets, were badly torn and distorted. A portion of the firebox was blown out of the boiler and landed 75 feet away from the engine. The boiler itself was torn from the frame, shearing the rivets at the smokebox, leaving it attached to the cylinders. The boiler itself landed across the main track bottom side up.

The Vulcan Flexible System of Staying for Lancashire Boilers

All steam generators after some years of service tend to develop defects, the nature of which vary with the type of generator and the conditions under which it has worked, and, in the case of the Lancashire type of boiler, one of the commonest defects met with is that known as grooving.

Grooving is primarily a mechanical defect caused by severe localized bending strains of such intensity that the surfaces of the affected plates are stressed beyond the elastic limit of the material. The repeated application of such strains tends to break down the structure of the metal, opening out the outer fibres when in tension and crushing them when in compression, with the result that cracks appear on the surface of the plate and in time extend into the metal until it fractures through. The parts of a boiler most liable to such action are those which, under working conditions, have a movement re-

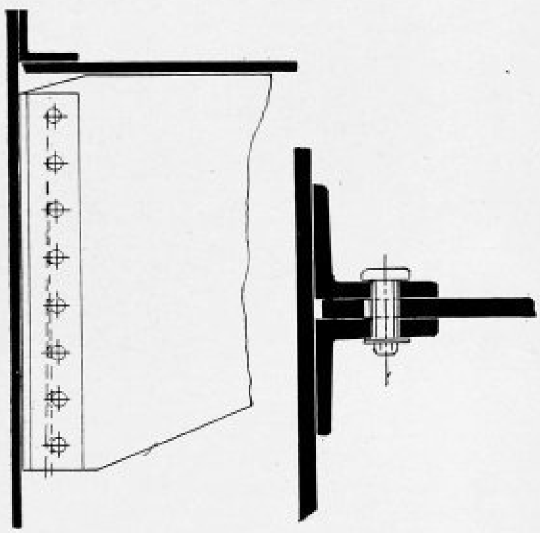


FIG. 1.—GENERAL ARRANGEMENT OF VULCAN PATENT, FLEXIBLE GUSSET. STAY-BOLT HOLES IN GUSSET PLATE ARE ELONGATED

lative to each other, and in thè case of Lancashire boilers the expansive movement of the furnaces relative to that of the shell is the principal cause of grooving at the front end plate and in the roots of the front end flanges or angles of the furnaces.

From gagings taken at the end of a number of Lancashire boilers it has been found that when steam is being raised from comparatively cold water the longitudinal expansion of the furnaces may be as much as 5/16 inch greater than that of the shell, and the tabulated results of gagings given herewith may be taken as showing the behavior of a boiler when steam is being raised under average conditions after a week-end stoppage for cleaning. Even after a boiler has been working for some time under normal conditions and the shell bottom has attained its usual temperature, the difference in the furnace and shell expansive movement may remain at as much as ¼ inch, but this amount will, of course, greatly depend on the system of firing employed.

If the working conditions are such that the furnace plates are liable to be heated to abnormal temperatures, due to a heavy deposit of scale or oily matter on the water side, or to the use of a system of firing by which a high furnace temperature is attained, or by a combination of these conditions, the expansion of the furnaces must necessarily be greater than the amount given above, and if no provision is made for the absorption of this extra movement, the front end plate and its stays and also the furnace flanges will be subjected to very severe strains, and grooving will develop very rapidly. If, in addition to the foregoing, the feed water is of a corrosive nature, the combination of mechanical and chemical actions will result in even more rapid development of grooving.

When working pressures were low and boiler diameters did not generally exceed 7 feet 6 inches, it was possible to use comparatively thin plates in boiler construction, and as such plates were less rigid than the thicker plates now necessary in modern high-pressure boilers, bending stresses, due to the expansive movement of the furnace, were not so severe or localized, and consequently grooving did not develop so rapidly.

It is necessary, if grooving action is to be minimized, that some portion or portions of the boiler should be made sufficiently flexible to absorb this expansive movement of the furnaces; and with this object in view, boiler designers have from time to time modified the design of front end plates, furnaces and staying, and the general trend has been in the direction of greater breathing space between the stays and

TABLE OF DEFLECTIONS AT FRONT END OF BOILER, 8 FEET DIAMETER, WORKING PRESSURE 160 POUNDS.

Front-end plate ¾ inch thick. Gusset angles 6 inches by 5 inches by 11/16 inch. Bolts 1⅜ inches diameter.

Pressure by Gage.	Deflection at Bottom of Gusset Stays.					Deflection Around Furnaces.						
	Left Wing.	Left Intermediate.	Center.	Right Intermediate.	Right Wing.	L.H. Side of L.H. Furnace.	Top Center of L.H. Furnace.	Between Furnaces at Center.	Top Center of R.H. Furnace.	R.H. Side of R.H. Furnace.	Bottom Center of L.H. Furnace.	Bottom Center of R.H. Furnace.
Hydraulic Test.												
160	3/32	5/32	7/32	5/32	3/32	2/32	5/32	3/32	5/32	2/32	3/32	3/32
260	4/32	7/32	8/32	6/32	4/32	2/32	7/32	5/32	7/32	2/32	5/32	5/32
Steam Test. Atmospheric Pressure.												
—	2/32	2/32	2/32	2/32	1/32	0	2/32	0	3/32	0	2/32	2/32
20	2/32	3/32	3/32	3/32	1/32	1/32	4/32	1/32	4/32	1/32	2/32	2/32
40	3/32	4/32	5/32	4/32	3/32	2/32	5/32	2/32	5/32	2/32	4/32	2/32
60	3/32	6/32	7/32	6/32	3/32	2/32	5/32	2/32	5/32	2/32	4/32	2/32
80	3/32	7/32	7/32	6/32	3/32	2/32	6/32	3/32	5/32	2/32	5/32	4/32
100	4/32	7/32	7/32	6/32	3/32	2/32	7/32	4/32	6/32	2/32	5/32	5/32
120/140	4/32	7/32	8/32	7/32	5/32	3/32	8/32	4/32	8/32	2/32	5/32	5/32
160	5/32	8/32	9/32	7/32	5/32	3/32	8/32	4/32	8/32	3/32	5/32	5/32

Fires light. Dampers open 3 inches to 6 inches.

the furnace crowns, or to the design of furnaces with a view to longitudinal elasticity. Many of these devices, however, have not been successful, and in some cases they have only transferred the trouble from one part of the boiler to another.

For some considerable time the Vulcan Boiler and General Insurance Company, Ltd., London, England, have had before them this problem of the prevention of grooving, and a description of an improved system of staying patented by them will be of interest to steam users.

The Vulcan patent flexible stay, as shown in Fig. 1, is a modification of the ordinary rigid gusset stay, consisting of the usual double angles riveted to the shell and front end plate. The gusset web plate is rigidly riveted to the angles on the shell, but turned bolts are substituted for the rivets

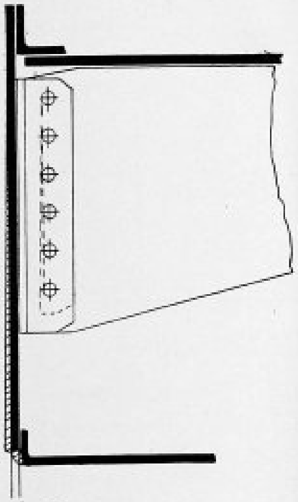


FIG. 2.—VULCAN FLEXIBLE GUSSET STAY

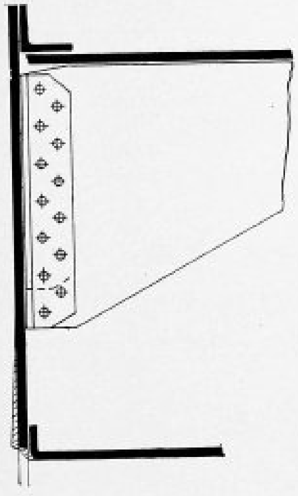


FIG. 3.—ORDINARY RIGID GUSSET STAY

Shaded areas show shape and deflection of end plate under working conditions.

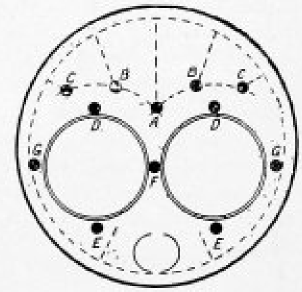
generally used for the attachment of this web plate to the angles on the front end plate. The bolt holes in the gusset plate are elongated, the clearance varying from a maximum at the bottom to nil at the top, and permit a certain amount of end plate movement before the stay takes any load. It will be seen that by varying the elongation of the bolt holes it is possible to design the staying so that the end plate is free to move through any pre-determined distance, and it is possible by this system to distribute the load evenly over all the bolts instead of practically the entire load coming on the toe rivets only, as in the case in the customary system of rigid staying. When the conditions of working are severe, such an arrangement of staying is of great value in reducing the strains that tend to cause grooving action or leakage from the rivets and seams at the front end.

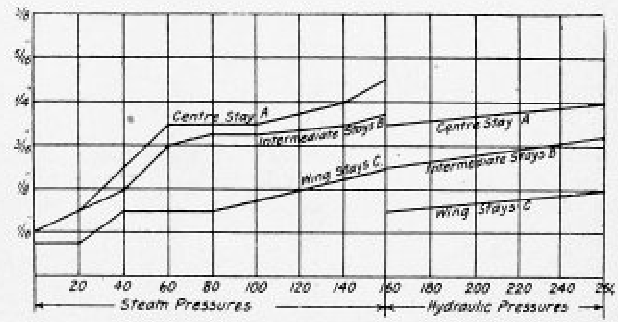
When the Vulcan patent system of flexible staying is fitted, the shape assumed by the end plate under working conditions is that shown by the shaded area, Fig. 2, and it will be seen that the deflection due to the furnace expansive movement and internal steam pressure is not localized, but is distributed over that portion of the end plate situated between the furnace crowns and the outer circumferential riveting by which the plate is attached to the shell, and the angle through which the plate is bent due to this movement is comparatively small, and severe local stresses are thereby avoided.

With a rigid system of staying, as shown in Fig. 3, it will be seen that practically all the movement due to furnace expansion, etc., has to be taken up by the front end flanges of the furnaces and a strip of plate usually 10 inches to 11 inches wide situated between the crowns of the furnaces and the bottom or toe rivets in the attachments of the gusset angles to the end plates. It will be seen from the shaded area, Fig. 3, that the angles through which the furnace flanges and end plate are bent are very much greater than is the case when the Vulcan patent flexible system of staying is fitted, and the stresses at these parts must necessarily be much more severe, resulting in fracture of the end plate, gusset angles, or rivets, in some cases after only a comparatively short period of service.

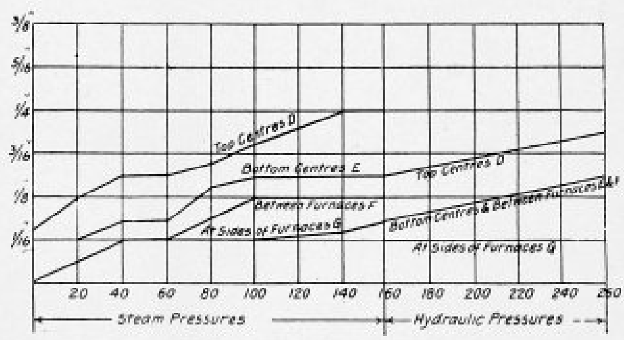
The Vulcan patent flexible system of staying has been fitted to a number of large modern high-pressure boilers, some of which were originally fitted with the ordinary rigid stays, and several of these boilers have been working for a considerable time with satisfactory results. With the boilers so fitted there has been an absence of the troublesome leakages so often

DIAGRAMS SHOWING DEFLECTIONS OF FRONT END PLATE AT POINTS INDICATED ON SKETCH THUS





DEFLECTIONS AT BOTTOMS OF STAYS.



DEFLECTIONS AROUND FURNACES

seen from gusset and furnace mouth riveting at the front end, and this in itself would point to a reduction in the severe strains at these parts, and the internal condition of the boilers after a period of service confirms this. As the behavior of this system of staying under varying conditions of stress will be of interest to steam users, a table is given showing deflections at different parts of the front end plate of a high-pressure boiler under hydraulic pressure tests, and when raising steam from comparatively cold water. These results are also shown in diagram form.

The boiler is 8 feet diameter and was made for a daily working pressure of 160 pounds per square inch. The end plate is ¾ inch thick and is fitted with five flexible gusset stays above the furnaces at the front end and two ordinary rigid gusset stays below. The bottom bolt hole of the center stay is elongated 9/32 inch, those in the intermediate stays ¼ inch, and in the wing stays 5/32 inch. An analysis of the figures reveals several points of interest, and it will be noted that the deflections under steam pressure are much greater than those at a corresponding cold-water pressure, this being principally due to the expansive movement of the furnaces forcing out the end plate. When steam at about 212 degrees F. was just issuing from the test tap, it will be seen that the upper parts of the furnaces had expanded through a distance equal to 1/16 inch more than the shell of the boiler, while at 40 pounds steam pressure the difference at these parts was equal to that caused by a cold-water pressure of 160 pounds per square inch—the pressure for which the boiler was constructed—and at 120 pounds steam pressure the deflection was just equal to that produced by the maximum cold-water test pressure of 260 pounds per square inch. The deflections at the bottom ends of the three centre gusset stays were of a similar amount, and it is interesting to note that at the full working steam pressure of 160 pounds the bolts were just in contact with the ends of the elongated holes in the gusset plates, thus showing that the end plate was practically free to move with the furnaces until the full working pressure was reached.

The foregoing figures are typical of a number of tests that have been made from time to time in connection with boilers fitted with the Vulcan patent system of flexible staying.—*Vulcan.*

Forced Draft

BY JOHN CARSON

When it is desired to fit a battery of boilers with forced draft, the first thing to be decided is the diameter of the fan disk. From practice it has been found that the diameter of the fan disk should be equal to .2 of the total grate area. Knowing the diameter of the disk it is then necessary to fix the area of the fan outlet. This should be found from the following:

$$\frac{\text{Grate Surface}}{\text{Fan Outlet}} = 21.17 \text{ square feet.}$$

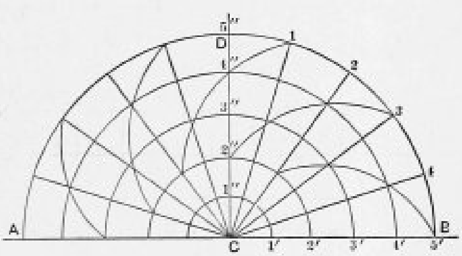


FIG. 1

The diagram Fig. 1 shows the method of designing the curve of vanes. *A B* is the diameter of the fan disk. *D B*, *C B* and *C D* are divided into the same number of equal parts. Join *C* 1, *C* 2, *C* 3, etc. With center *C* and radius *C* 1′, *C* 2′, etc., describe arcs 1′ 1″, 2′ 2″, 3′ 3″, etc. Where these arcs cut the radii *C* 1, *C* 2, etc., are points on the curve of the vane.

To design the air casing round the fan disk proceed as follows:

The dotted circle, Fig. 2, represents the diameter of the disk. The center line of the outlet is tangential to the disk. Draw

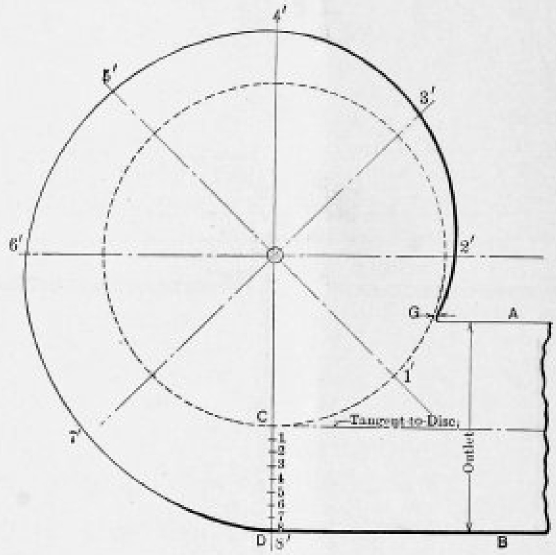


FIG. 2

the fan outlet *A B*. Divide the distance *C D* into eight equal parts, and divide the disk into the same number of equal parts. With center *O* and radius *O* 1 mark off 1′. With center *O* and radius *O* 2 mark off 2′. With center *O* and radius *O* 3 mark off 3′, etc., and these are the points on the curve forming the casing round the disk. Some firms make the distance between the disk and casing at *G* equal to 1 inch, and run the casing away to meet this; but this distance can be anything from ⅝ inch to 3 inches.

Table I was made up from actual practice and was found to give first-class results.

$$\text{Therefore approximate area of fan disk} = \frac{\text{Grate Area}}{5.24}.$$

$$\text{Area of fan discharge} = \frac{\text{Grate Area}}{20.3}.$$

Area of fan inlet = discharge × 2.15.

TABLE I

Total greate area	293	150	416	416	416	511	387	560	540
Number and diameter of fans	1—96″	2—60″	2—84″	2—84″	2—84″	2—90″	2—84″	2—96″	2—100″
Area of 1 fan disc in square inches	50.26	19.63	38.48	38.48	38.48	44.178	38.48	50.26	54.5
Area of fan discharge	15.75	8.5	20.2	20.2	20.2	23.3	19.6	24.	30
Area of fan inlet	30.06	19.63	38.48	38.48	38.48	54.52	38.48	10.14	......
Grate area divided by fan discharge	18.6	17.65	20.6	20.6	20.6	21.9	19.85	23.3	18
Area of inlet divided by area of discharge	1.91	2.31	1.91	1.91	1.91	2.34	1.97	2.5	......
Area of fan disc divided by area of fan discharge	3.19	4.62	3.81	3.81	3.81	3.96	3.91	4.2	3.6
Grate area divided by area of fan discs	5.83	3.83	5.4	5.4	5.4	5.78	5.04	5.57	4.9

One of the most violent locomotive boiler explosions occurred at Muncy, Pa., on the Philadelphia & Reading Railroad, March 1, killing four men and wrecking six cars. The boiler had a Wooten type firebox, the crown sheet of which tore loose at the tube sheet, and went down against the fire-door sheet. The frame was twisted and broken, but the smokebox remained firm on the frame, and the boiler itself was hurled a distance of 75 yards. Some stay-bolts were pulled out through the bolt holes, and others had the appearance of having been cut off. The cause of the explosion is attributed to low water.

A Simple, Accurate and Positive Method for Securing the Template for a Segment of a Sphere

BY J. T. BRADBURY

I have seen a number of different ways for getting such a pattern, both by projection and triangulation, for a job of this kind, where the plates have to be heated and dished and then beaten out to shape, thereby changing any layout made on the flat, but I have never yet come across one that, to my mind, is as simple and easy as the method I have the pleasure of presenting here.

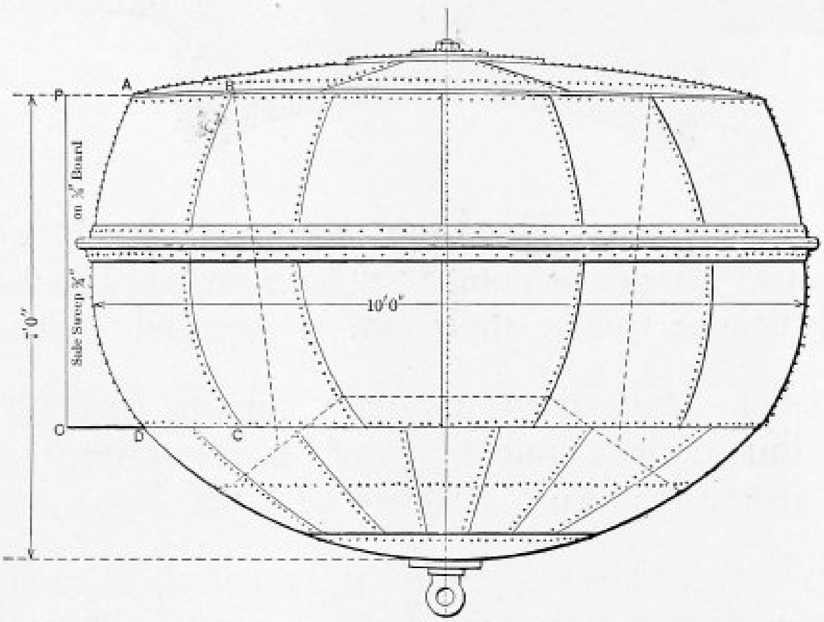


FIG. 1

We will take, for example, a type of bell buoy known as the Trinity House pattern, in use on our Canadian coast, a rough sketch of which is shown in Fig. 1. It is understood, of course, that a full-size half-front elevation be drawn on the blackboard.

It is required to get a mold or framework for segment *A, B, C, D* in sketch, Fig. 1, that will fit on the outside, each course consisting of twelve plates. We first cut out a sweep from a board ¾ inch or ⅞ inch thick, with a radius from the center of the buoy to the rivet line on the round about at *A*, using the concave piece, also one from the center to the rivet line at *D*, again using the concave piece, these two forming the top and bottom of the mold to mark the rivet lines at *A, B* and *C, D*. Now cut two more pieces for the sides, both having the same radius, being the same as that on which the curve from *A* to *D* is struck, marking the rivet lines at *A, D* and *B, C*. Now lay the top and bottom pieces on a table at the same distance from a center as their radii. Draw a line from the center to the circumference, extending it outward to get the miter or angle at *H, F*, Fig. 2. Divide the circumference into the number of parts required to make the course, in this case twelve being the number; measure off the distance on the circumference from *H* to *K*, Fig. 2, the length required

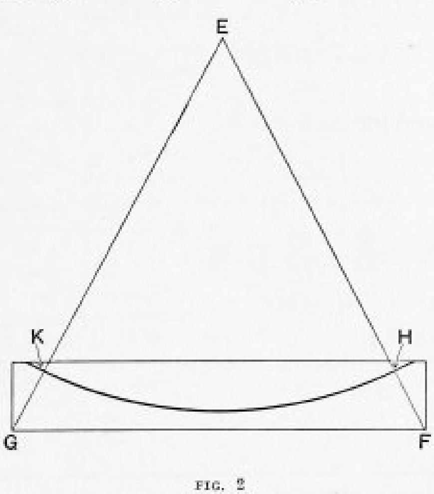


FIG. 2

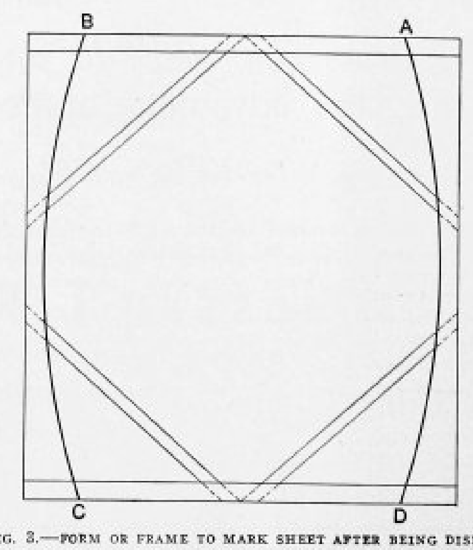


FIG. 3.—FORM OR FRAME TO MARK SHEET AFTER BEING DISHED

for one-twelfth the circumference. Draw the line E, G, cutting the circumference at K, then G, K and H, F will be the angle at which the two side pieces will be fastened. Proceed in the same way with the bottom piece. The angle or cut must be carefully marked, as on it depends the important essential—

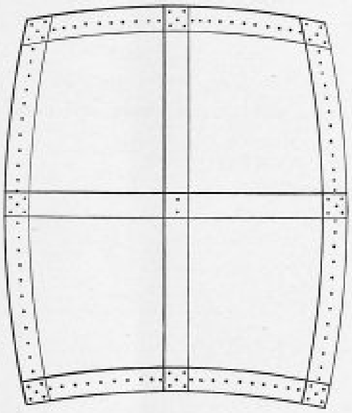


FIG. 4.—TEMPLATE READY FOR MARKING NEXT SHEET

good holes. The angle or cut of the side pieces at O, D and P, A, Fig. 1, will be at right angles to the center line of the buoy. The length of the curve at A, D, Fig. 1, should be two thicknesses of the ¾-inch or ⅞-inch board used, less than the actual length on the sketch, to allow the rivet line to be marked all around outside of the mold, the top and bottom pieces being nailed to the side pieces. Allowance ought to be made for inside and outside laps by extending the top and bottom corners of the outside lap half the difference necessary between the outside and inside laps.

After tracing the rivet line on the dished plate lay out the holes required with dividers, then punch all holes. Take strips of light material about 14 or 16 gage, 3 inches or so wide, clamp them on the outside of the segment; mark and punch same, then bolt them on in the original position. Fasten each corner with four small rivets, also rivet cross pieces from side to side and top to bottom, as shown in Fig. 4. You will then have a template that will be true and fair for all time, and each segment will be the same as the other, so that if a new plate were needed no trouble would be encountered in replacing the old one, each plate being interchangeable. The mold ought to be beveled on the inside edge all around to allow the outside to bear evenly on the plate.

I do not know whether this method has been used by any one previous to my using it, therefore I will not claim to be the originator, but so far as I am concerned I never heard of it prior to my first experience with it.

Practical Methods for Simple Laying Out Jobs

BY J. SMITH

In answer to Subscriber in the January BOILER MAKER for information regarding the layout of circular courses, it is not stated definitely that he wishes to know how to lay out such a course, but requires information regarding the thickness of material used. The most correct way and the one which does away with the necessity of adding or subtracting the three and one-quarter times the thickness of material used is to figure the diameter from the neutral diameter, as shown in Fig. 1. We will take a circular course supposed to be 24½ inches inside diameter, made of ½-inch material, add to your inside diameter one thickness of material, making 25 inches neutral diameter. Using the decimal 3.1416, and multiplying by the diameter 25, we have the length of plate required, 78½ inches to the seam line, the lap to be allowed.

To find the length of angle iron required for an inside diameter the rule given by John Courtney in the *Boilermakers' Assistant* is a good rule to use, care being taken to have the iron at an even heat in bending, for if one part is hotter than another that part will stretch more. Bending with as uniform an heat as possible this rule will give good results. Fig. 2 shows an angle ring with the flange out. To the inside diameter add twice the slant thickness of material at the heel of the iron, as shown by line in Fig. 2, and multiply the sum by 3.1416, which will give us the length required. When we have an outside diameter, as in Fig. 3, subtract twice the thickness of iron at heel from the outside diameter and multiply by 3.1416, giving us the length required for an outside diameter.

The allowance for taper courses can be solved by the layout in Fig. 4. Erect the elevation of the course as at A, B, D, C. Make A B the neutral diameter of course at the larger end and C, D the neutral diameter at the small end, which will be two thicknesses of material smaller. On each side of A, C and B, D erect another elevation of the course as shown. Divide these elevations into equal parts, as shown by lines 1, 2, 3, 4, 5. Now with a square set to line B, D and touching

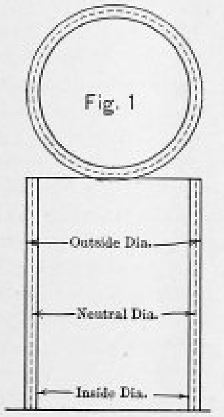


Fig. 2

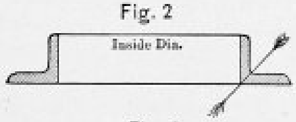
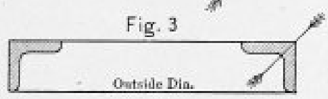
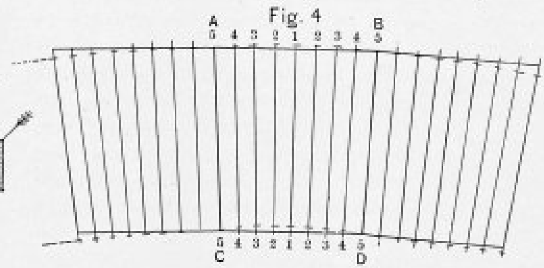


Fig. 3





point 5 mark where the square intersects line 4. From this point on line 4 set the square and mark on line 3, continue until line 1 is marked, then set the square to line A, C at point 5 and mark line 4, and so on till you reach line 1 again. Now set the square to the left of line A, C at point 5, and mark where it strikes line 4. Continue until you have thus marked all lines on each side of A, B, C, D. Now with trams set to distance A, C mark off from the points found at the top the distance A, C on each line, which will give us the taper at the bottom. On each side of line 1 at the top set off half the circumference for the large end. Now, for a fair fit, the bottom should be six and one-half thicknesses of material smaller. Deduct that amount from the circumference of the large end, and put half the remainder on each side of line 1 at the bottom along the dotted line. Generally the circumference extends a little beyond the points found, but this can be easily adjusted by squaring off from the last points and tracing a line through as shown at the left of Fig. 4. This rule was given in an early edition of THE BOILER MAKER, and has been used with good results by the writer.

Summary of Corrosion Tests of Wrought Iron and Steel

EARLY TESTS

When the question of the relative corrosion of iron and steel became a very pertinent one, numerous laboratory or accelerated tests were conducted with wrought iron and steel pipe under various conditions resembling, as near as possible, those of actual service. A summary of these early tests is interesting in view of the results of later comparisons of pipe found in service (Table I):

TABLE I.—SUMMARY OF RESULTS OF INVESTIGATIONS OF THE CORROSION OF WROUGHT IRON AND STEEL.
(From American Society for Testing Materials, 1908—Profs. Howe and Stoughton)
(From Iron Age, February 14, 1907—F. N. Speller).

No.	Date.	Duration of Test.	Conditions of Test.	Authority.	Material Tested.	Relative Loss of Weight
1	1897	2 years	Sea water, normal temperature.	Prof. H. M. Howe	Steel skelp	117%
					W. I. skelp	100
2	1897	2 years	River water, normal temperature.	Prof. H. M. Howe	Steel skelp	94%
					W. I. skelp	100
3	1897	2 years	Weather	Prof. H. M. Howe	Steel skelp	103%
					W. I. skelp	100
4	1901	64 weeks	Aerated distilled water, normal temperature	U. S. Navy department	Charcoal iron	100%
					Pipe steel	94.5
5	1904	6 months	Aerated brine, normal temperature	Laboratory National Tube Co	Puddled iron	100%
					Pipe steel	106
6	1905	3 months	Aerated water, 180° F.	Laboratory National Tube Co	Puddled iron	100%
					Pipe steel	90.6
7	1906	3 months	Aerated brine, 180° F.	Laboratory National Tube Co	Charcoal iron	80%
					Puddled iron	100
					Pipe steel	75.3
8	1906	3 months	Aerated sea water, 180° F.	Prof. H. M. Howe	Charcoal iron	94.4%
					Puddled iron	100
					Pipe steel	94.2

Thus the results of these various tests on materials manufactured from six to fifteen years ago show on the average that steel in general lost 97.2 percent as much weight by corrosion as wrought or puddled iron, and 96.1 percent as much weight by corrosion as charcoal iron.

LATER TESTS

Following these so-called laboratory experiments several investigations were carried on to determine the relative corrosion of wrought iron and steel in actual service. Prof. T. N. Thomson, principal of the International Correspondence Schools in March, 1906, installed alternate pipes of these two materials in a hot-water line, and at the end of a year discovered that steel pipe had approximately a 7½ percent longer life than wrought iron under such conditions. (American Socety of Heating and Ventilating Engineers, 1908.) Again, from Nov. 18, 1907, to Nov. 30, 1908, a committee, of which Mr. Thomson was chairman, appointed by the American Society of Heating and Ventilating Engineers, carried on a similar test with alternate lengths of steel and iron pipes from several makers. This experiment checked up well with the first one, and resulted in a report which concludes as follows: "We believe (this test) demonstrates that modern steel pipe of good quality is at least as durable as modern strictly wrought iron pipe of good quality, and is very much superior to a poor quality of wrought iron in this class of work." (American Society of Heating and Ventilating Engineers, 1909.)

Corrosion tests in running mine water were carried on by Prof. Thomson, the Pittsburg Coal Company, the H. C. Frick Coke Company (*Iron Age*, July 12, 1906), and others, these indicating that steel is at least equal to wrought iron in resisting corrosion. The same result is evident on a test now in its seventh year comprising alternate iron and steel pipes in an atmospheric ammonia condenser at the Isabella Furnaces, Etna, Pa., and on several other parallel tests on ammonia condenser pipe. A number of gas companies conducted tests in moistened ashes, which resulted in the use of steel pipe for such work. A test carried on under atmospheric conditions with alternate panels of iron and steel pipe in the river wall at the National Works of the National Tube Company, McKeesport, Pa., shows no marked difference between the corrosion of the two materials after being subjected to the elements for nearly six years.

OPINIONS OF AUTHORITIES

The results of the foregoing tests, and many others not mentioned covering a wide scope, have led careful investigators to the conclusion that there is no inherent difference in the rust resisting powers of steel and wrought iron, that these two materials when subjected to the same conditions of service corrode at much the same rate. In his text book, "The Metallurgy of Iron and Steel," Bradley Stoughton, one of those who has carried out exhaustive investigations, says: "The evidence goes to show that properly made steel corrodes no more than wrought iron." J. Newton Friend, in his recent book entitled "The Corrosion of Iron and Steel," states: "It would appear, therefore, that when everything has been taken into consideration, there is practically nothing to choose between wrought iron and steel as at present manufactured," and finally concludes with these words: "These and many other instances might be cited as illustrating the fact that good steel corrodes at much the same rate as good wrought iron." A. Sang, in a thorough resumé of the question entitled "The Corrosion of Iron and Steel," says: "Properly protected steel and iron rust to about the same extent, the steel doing so more uniformly," and adds, "The best quality of charcoal iron is practically as resistant as the best quality of steel used for similar purposes." In regard to pipe steel Sang remarks: "The carefully acquired experience of the largest manufacturers of tubes in the world which induced them recently to abandon the manufacture of wrought iron pipes, teaches that the use of steel in place of iron—at least in the United States—for the special purpose of tubing, is to be preferred; the tendency of the steel to pit is somewhat less than that of iron, and it welds at the joint fully as well."

RESULTS IN SERVICE

Within the last two years investigations have been made to ascertain whether the outcome of laboratory experiments and service tests of short duration, as well as the opinions of authorities, are borne out in actual service. Comparisons of wrought iron and steel were sought in pipe lines where conditions were as nearly constant as possible from pipe to pipe. Hot and cold water lines and exhaust steam lines meet these requirements possibly better than any others, especially hot

TABLE II.—SUMMARY OF RESULTS OF INVESTIGATIONS OF THE CORROSION OF IRON AND STEEL IN ACTUAL SERVICE.

No.	Date.	Locality.	Length of Time Pipe Lines Were Installed.	Character of Service.	Authority.	Number of Cases on Record.	Average of Deepest Pits.		References for Details and Remarks.
							Wrought Iron.	Steel.	
1	1910	New York City bath-houses	3 years and over.	Hot water supply service.	Prof. Ira H. Woolson, Columbia University.	89 samples secured, of which 17 are wrought iron and the remainder steel.	Equal 100%	100%	Engineering News, December 3, 1910, page 630; N. T. C. Bulletin No. 2. This was a test of iron and steel pipe in actual service continued to destruction.
2	1910	Frick Coke Co. power plants	6 months to 7½–8 years, varying with the comparisons secured.	Boiler feed water lines.	Research Laboratory National Tube Co.	21 lots comprising 52 samples, of which 26 are iron and 26 steel.	.112″ 100%	.108″* 96%*	Engineering Review, April, 1911; N. T. C. Bulletin No. 3; American Society Heating and Ventilating Engineers, 1911. Pipe samples secured from lines in actual use. In 22 cases of adjacent iron and steel pipes in same lines, 13 comparisons favor steel and 9 iron.
3	1911	Cresson (Pa.) coal fields.	6 months to 10 years, varying with the comparisons secured.	Hot and cold water boiler feed lines; pump discharge lines.	Research Laboratory National Tube Co.	9 comparisons of iron and steel found together.	.100″ 100%	.085″* 85%*	Pipe samples secured from lines in actual use. In 9 cases of adjacent iron and steel pipes found in same lines, 4 comparisons favor steel and 2 iron; in 3 cases the steel and iron are equally corroded.
4	1911	Allegheny General Hospital.	Between 7 and 8 years.	Hot water supply service.	Research Laboratory National Tube Co.	69 samples from hot water lines, 42 wrought iron and 27 steel.	105″ 100%	.105″ * 100%*	Conditions those of actual service, and pipe was tested to destruction. In 13 cases of adjacent iron and steel pipes found in same lines, 7 cases favor steel and 6 iron.
5	1911	New England Investigation.	2 years to 17 years, varying with the comparisons secured. Average 9 years.	Hot and cold water, live and exhaust steam, brine, boiler blow off lines, etc..	Dr. W. H. Walker, Director Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology.	54 comparisons of iron and steel found together, in hot water and steam lines.	.069″ 100%	.063″* 91%*	Engineering News, December 21, 1911; Journal of New England Water Works Assn. January, 1912. Actual service conditions. In 54 cases of adjacent iron and steel pipes found in same line, 20 favor steel and 18 iron, 9 show no difference in corrosion and 7 no corrosion at all.

NOTE—Depth of pitting in wrought iron samples considered as 100% in all cases.
(*) Calculated from the deepest pit in each sample.

water service lines where the pressures, temperatures and flow of water in adjacent pipes is practically constant, and where the varying conditions of exterior corrosion and electrolysis are not encountered, and where the corrosion is generally of such violence that after from three to ten years' service there is no difficulty in measuring its effect. In examining the specimens secured the deepest pit in each piece was usually considered as a measure of the corrosion, but the general condition of the pipe was also taken into account. In no case was the origin of the materials known absolutely, but the results may be taken as typical of the comparative rust-resisting qualities of wrought iron and steel as manufactured about eight or ten years ago.

The first investigation of this kind was made by Prof. Ira H. Woolson, of Columbia University, who secured 89 samples of corroded pipe from seven bath houses in New York City. Seventeen of these specimens afterward proved to be wrought iron and the remainder steel, so that an excellent comparison of the two materials was secured. After a careful examination Prof. Woolson declared: "In my judgment from the evidence collected there was absolutely no difference in the corrosion of the two classes of pipe (*i. e.*, wrought iron and steel). They appear to be equally susceptible to attack." This pipe had been in actual service on an average of probably five years and it was tested to destruction.

In 1910-1911 a search was instituted in the hot water boiler feed lines of the H. C. Frick Coke Company power plants to secure samples of steel and iron pipe adjacent to each other in the same line. Means were discovered to identify the material in the lines, which resulted in the finding of a number of cases where steel and iron pipes had been put in together. When these were removed and opened up for an examination of the pitting, it was found that the average of the deepest pit in each of the twenty-six iron samples was .112 inches, and in the twenty-six steel samples .108 inches, that in twenty-two cases where the two materials were found together thirteen of these "pairs" favor steel and nine iron, as far as resistance to corrosion is concerned.

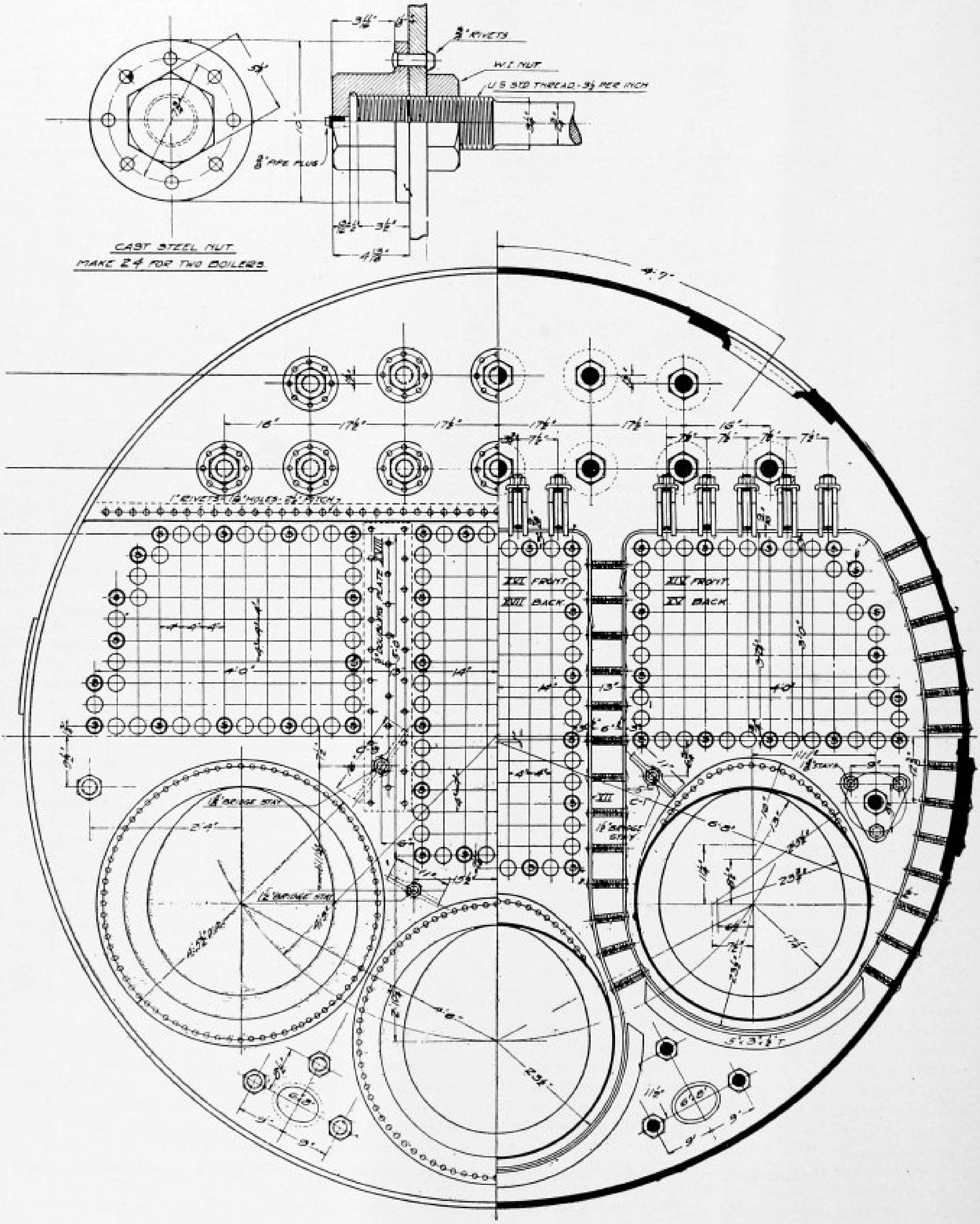
A similar investigation in the power plants of several Central Pennsylvania Coal Companies resulted in the discovery of nine "pairs" of steel and wrought iron pipe which had been placed side by side when the line was laid. Four of these comparisons favor steel and two iron, while in three cases the corrosion was equal; the average depth of pitting in the steel pipes was but 85 percent of that in the iron.

The American Institute of Steam Boiler Inspectors of New York City held its second annual dinner at the Broadway Central Hotel Feb. 21. An address was made by Mr. Joseph H. McNeill, chief inspector of boilers for Massachusetts, on "The Advancement and General Adoption of the Massachusetts Boiler Laws in the United States and the Philippine Islands." Letters of regret were read from Col. E. D. Meier, president of the American Boiler Manufacturers' Association; Inspector-General George Uhler, of the United States Steamboat Inspection Service, and Chief Inspector Wirmel, of Ohio. The toastmaster was the retiring president, Mr. T. T. Parker. To fill the executive offices of the association for the coming year the following were elected: President, J. M. Winter; vice-president, J. G. Shaw; secretary, R. A. Thomson, Travelers' Insurance Company; treasurer, James White; executive committee, Charles H. McAleenan, chairman; F. C. Williams, J. G. Gillespie, L. A. Turnbull, A. J. Lappan.

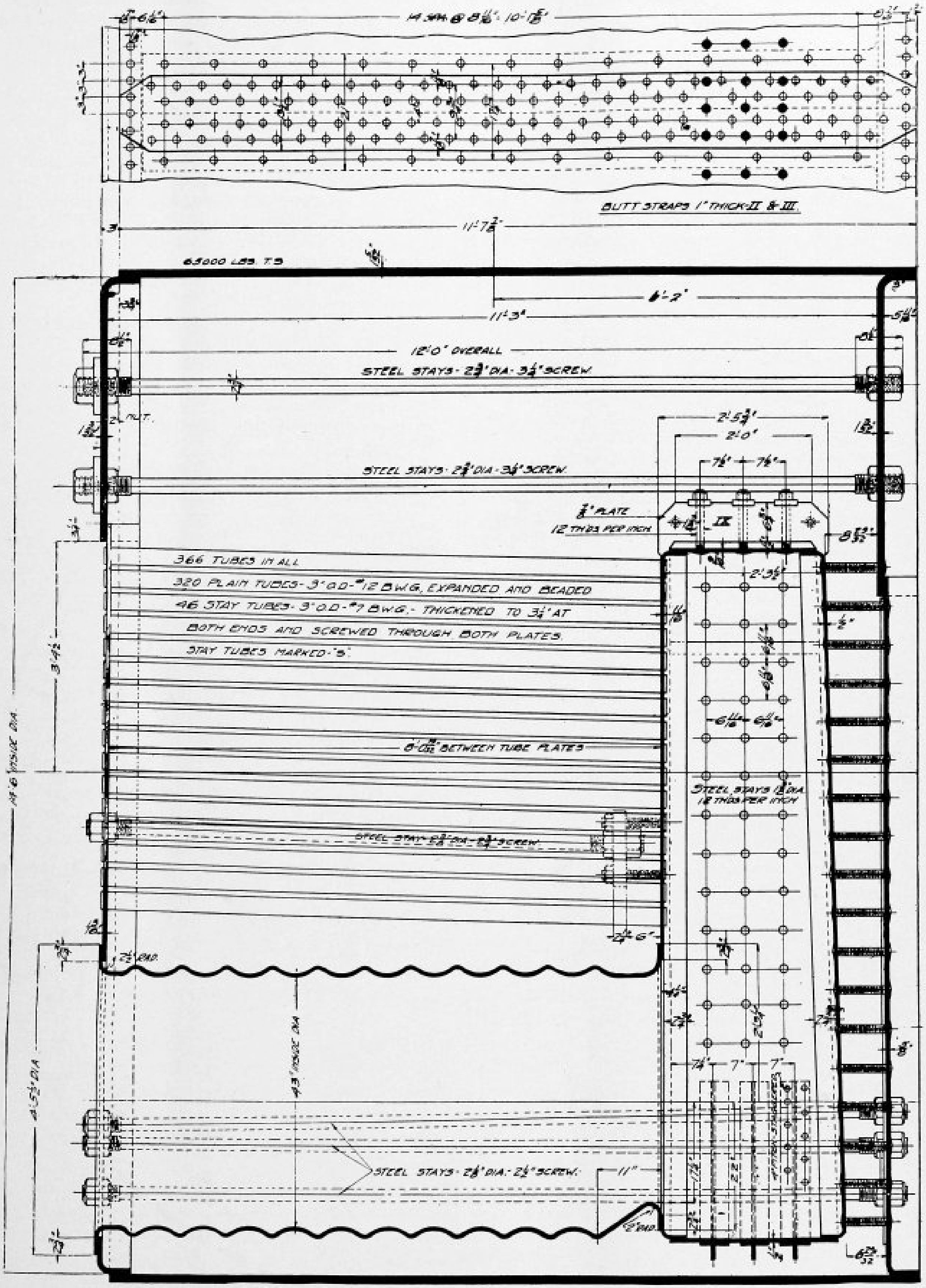
The recent failure of a steel standpipe, 140 feet tall and 20 feet in diameter, which had been in service nearly twenty-five years, has been the cause of some speculation as to what caused the failure. It appears that the structure was designed with a factor of safety of 3, whereas at the present time a factor of safety of at least 5 or 6 would be used. The material was somewhat brittle, and the initial failure apparently occurred by rupture through a line of rivets in the bottom course.

Advanced Scotch Boiler Construction

The Marine Review for May, 1909, reproduced drawings of a large boiler built on the Pacific Coast and the shell of which was constructed of only two plates, these plates being 25 feet 1½ inches long and 11 feet wide. Herewith we are able, through the courtesy of the American Shipbuilding Company, to present illustrations of two large boilers which the company now has under construction for the steamer *Owego*, of the Erie Railroad fleet, and the shells of which are also built with only two plates. These are the largest boilers so far built on the Lakes in which this type of construction has



HALF-END ELEVATION AND TRANSVERSE SECTION OF BOILER FOR THE STEAMER OWEGO



LONGITUDINAL SECTION OF THE BOILER FOR THE STEAMER OWEGO been followed, and, in fact, practically represent the limit of existing rolling mill capacity, being 23 feet long and 11 feet 8 inches in width. The plates were rolled by Worth Bros. Company, Coatesville, Pa.

These boilers may be fairly said to embody the most advanced ideas in the construction of modern marine steam generators, and several features of interest will be noted, though probably none can be said to be original.

The two-piece front head eliminates seams behind the breeching and air casings, the boilers being designed for positive mechanical draft, and the calking edge of the single seam faces into the breechings or smoke casing, where its entire length is accessible.

The flanged mouth furnace avoids the difficulty of making fits between the furnace and head, and which is unavoidable with the flanged head sheet, and, furthermore, makes for a longer and more roomy stokehold.

The distance between the nests of tubes and between the tubes and the shell permits of access to every part of the interior without difficulty, and manholes, other than the statutory opening above the tubes, are not required. Openings of any kind behind air casings, or where not in plain view at all times, are eliminated, although hand and cleaning-out holes (not shown in drawings) have been liberally supplied.

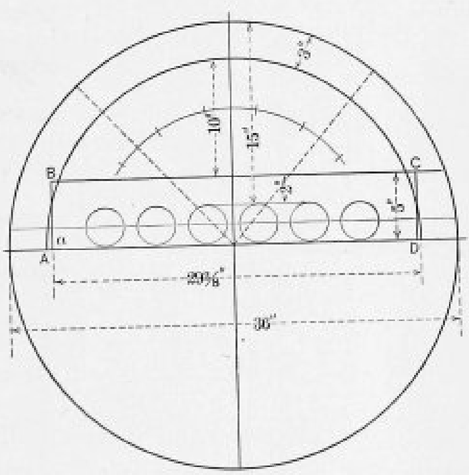
Interest will, however, center chiefly about the elimination of the girth seam and scarfed butt-straps, which, as is well known, make permanently tight work difficult.

The boilers are being built to the designs of Babcock & Penton, Cleveland and New York, and for a working pressure of 170 pounds.—*The Marine Review.*

Bracing Boiler Heads

BY JOHN COOK

Herewith is a table which I hope may help somebody in figuring the areas of the segment in a boiler head to be braced. I worked up this table as I laid out the heads, for I had a variety of work and different heights to put the tubes, so it was quite a job to figure out how many braces I could get in. The



ROUGH SKETCH OF 36-INCH HEAD

sketch shows about how I got them. It shows a 36-inch head; the center of the top row came 1½ inches above the center line. The tubes were 3 inches diameter, and therefore the top of the tube was 3 inches above the center line, leaving 15 inches from top of the tubes to the top of the flange.

It is usual to let the flange take care of a space 3 inches from it; therefore we will draw the 30-inch semi-circle as shown on the sketch. The tubes will take care of at least 2 inches above them, so draw the line *B-C* 2 inches above the top of tubes. Now if we lay the square on the center line *A-D*, and draw the lines *A-B* and *D-C* so they will divide the curve shown by dotted lines about equally as shown, then we have a rectangular piece to deduct from the upper half of the area of the 30-inch circle.

The area of a 30-inch circle is 706.86, half of that is 353.43. The rectangular piece will measure 29⅜ by 5 inches, and $29.375 \times 5 = 146.875$ and 146.875 from $353.43 = 206.555$, or, say, 206, which is near enough. Then 206 multiplied by the pressure and divided by the strength allowed for the brace will give the number of braces, in this case $206 \times 100 = 20{,}600$ and $20{,}600 \div 6{,}000 = 3$ with 2,650 pounds or over, so it will be safe to put in four braces, or if we use 5,000 as the strength of the brace, it will be $20{,}600 \div 5{,}000 = 4$, with 600 pounds over. Still, four braces will do. I never allowed over 5,000 for any brace that was welded.

Also, in every case, I would get the area of tubes and get out the up-take about 1/7 more area than was in the tubes; by doing this I never heard of complaints of bad drafts.

By keeping a memorandum of these it helped me considerably, as all I had to do was to look up any sized boiler and see where and how many tubes or braces were needed and where they went in.

Diameter of Boiler	Height Above Tubes	Area to be Braced
Inches	*Inches*	*Square Inches*
36	15	206
36	16	235
42	17	297
42	18	331
42	19	366
48	18	365
48	19	404
48	20	444
48	21	485
48	22	526
54	18	396
54	19	439
54	20	483
54	21	528
54	22	574
54	23	620
60	20	519
60	21	568
60	22	618
60	23	668
60	24	720
60	25	772
60	26	824
60	27	877
66	23	714
66	24	769
66	25	825
66	26	882
66	27	940
66	28	998
66	29	1,056
66	30	1,115
66	31	1,174
72	26	937
72	27	998
72	28	1,061
72	29	1,124
72	30	1,187
72	31	1,252
72	32	1,317

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Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

The importance of the forthcoming convention of the American Boiler Manufacturers' Association at New Orleans, March 12 to 15, has been strongly emphasized recently through the engineering press, and undoubtedly these appeals will meet with a ready response from those whose interests are affiliated with this industry. Whatever is done at this meeting we are sure will have a marked influence upon the future progress towards better standards in boiler construction, and to that much-to-be desired step—the formation of uniform boiler rules through the country.

During the whole history of boiler making up to a period beginning about five years ago there has been no means available for joining boiler plates together except by riveted joints. All boiler flues, except those of large diameter, have been joined to the flue sheets by expanding them into the flue holes, then beading over and calking the ends. Flues of large diameter have been riveted in flanged flue holes. Five years ago, however, the attention of boiler makers was turned to a process of welding called "autogenous welding," by which two separate pieces of metal could be united into one solid mass by fusion. In this process a flame or other source of heat of much higher temperature than the melting point of the metal is applied at the point where the two pieces are to be united, so that the metal at that point will be liquefied and flow together in a solid mass before the surrounding metal has time to conduct the heat away from the point which is being welded. Two methods of accomplishing this have been devised and brought to a very useful state of development. The first is the oxy-acetylene process, with which most of our readers have become familiar through these pages or by personal observation of the practical use of this system. The other process is known as electric welding, or arc welding, in which the heat for fusing the metal is applied by means of an electric arc. A very successful apparatus of this kind has been applied recently in several railway repair shops, particularly at the Hornell shops of the Erie Railroad. The details of this apparatus and many examples of its use will be found on another page in this issue. The best results at the Hornell shops have been obtained in the repair of mud rings, patching firebox sheets and welding up the seams of fireboxes. Some very remarkable savings in the cost of doing such work have been made in this respect, and the results warrant careful investigation by those who are concerned with boiler repair work, whether it be in railway, contract or marine shops.

A very useful suggestion is made by one of our contributors this month in which he urges apprentices to strike out for themselves as soon as they have served their time in the shop where they received their training. This, of course, is not meant as a hard and fast rule to be implicitly followed, and is no reflection upon the shop where the apprentice has served his time, as that might be anything from a small, poorly equipped shop to the largest and most modern plant in the country, as the case might be. There are some cases, however, particularly in some of the railroad shops, where the apprentice has been trained by his employers at considerable expense for which his services at the time are by no means a sufficient recompense. For this reason, there is a certain amount of loyalty which influences the apprentice to remain for a reasonable length of time in the shop where he has received his training. The advantage of an occasional change from one shop to another, however, is the opportunity which is gained for personal observation of a great variety of shop practice and different methods of boiler work. Right here we would urge the apprentice not to neglect the means which are always available in the shape of scientific books and technical and trade papers, which will help to round out his education and keep him in touch with the many details of shop practice which otherwise would be very unlikely to come under his personal observation.

New Improved Engineering Specialties for Boiler-Making

A New Marine Watertube Boiler

The watertube marine boiler shown in the accompanying illustrations, is an entire departure from the generally accepted type of marine boiler, as the numerous headers and expanded nipple connections usually used are eliminated. There are absolutely no joints or connections except the ends of the generating tubes, which are expanded into the water legs or flitches.

These boilers are built by the Charles Ward Engineering Works, Charleston, W. Va., in two types and of varying sizes to meet requirements. Fig. 1 shows a boiler which is particularly adapted for vessels of limited height between decks and moderate forced draft. The steam and water drum is located over the front flitch and at the lower end of the tubes. Circulation is provided by large openings in the bottom of the drum, registering with the rectangular passages in the water legs, delivering an ample supply of water to the generating tubes. The return from the upper flitch to the drum is through the top row of four-inch tubes.

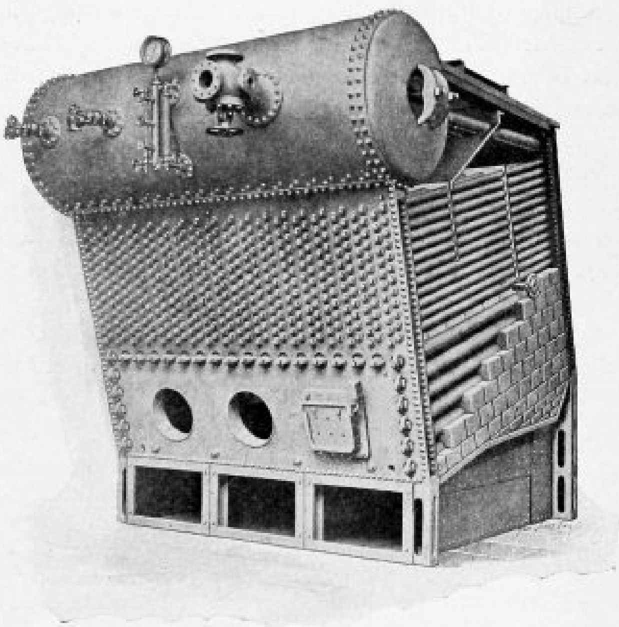


FIG. 1

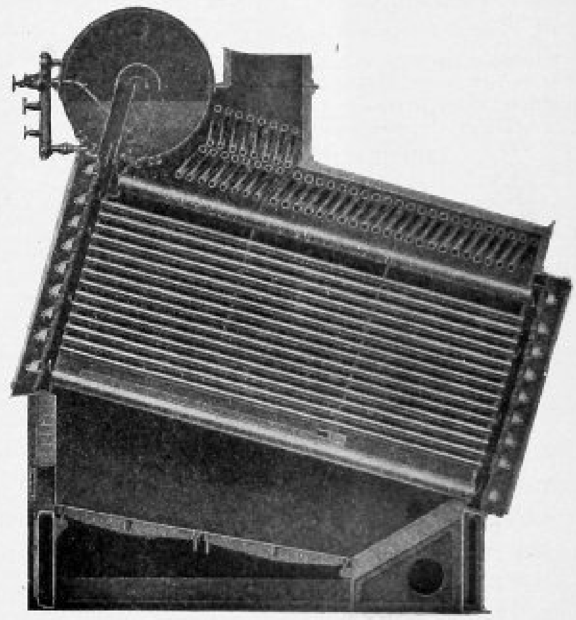


FIG. 2

The boiler shown in Fig. 2 has much larger passages for the circulation, and is designed for forced or natural draft and the greatest economy, having a superheater and a feed water heater. In this boiler the drum is in the front on the high side; the upper portion of the front flitch is enlarged where it is riveted to the drum; this chamber is divided by a diaphragm into two parts, one of them forming a passage from the drum to the large down-flow tubes, the other receiving the ends of the generating tubes, thus completing the circulation and delivering above the water line in the drum.

The water legs, or flitches, are constructed of steel plates, ¾ inch in thickness, forming the tube and hand-hole sheets. These sheets are spaced about 3½ inches apart, stayed to each other by improved and patented continuous stays, dividing the water leg into a number of rectangular passages, as shown in Figs. 3 and 4. T-shaped retaining grooves are milled in the tube and hand-hole plates approximately 6 inches from center to center. In these retaining grooves are fitted, in sections, a continuous I-section stay plate connecting the two sheets, thus forming the rectangular passages. This construction is claimed to be much stronger than any other method of supporting flat surfaces, as the connection is practically a continuous line, and the load per inch of stay is equal to the distance from center to center of the stays. multiplied by the working pressure, or only 1,800 pounds per lineal inch of stay for 300 pounds of steam, compared with 10,800 pounds per stay for the usual method of staybolting on 6-inch centers. Expansion and contraction is provided for by the flexibility of the stay plates, and the movement of the sectional stay in the retaining grooves. The troublesome question of leaky and broken staybolts is entirely eliminated, as there are no screwed or riveted stays in the boiler and no holes through the plates.

Each header, or flitch, in the moderate sizes, is constructed of one plate, folded through the center (Fig. 2), the edges channeled, flanged, or lapped and riveted, eliminating, as far as possible, all riveted joints, except the connections to the steam drum, which are flanged and riveted. Hand-holes covering a group of tubes, or individual plugs opposite each tube, give access for cleaning and renewals.

The steam and water drum is of large proportions, giving ample steam space and a steady water line. It is composed of one sheet, the joint being a very heavy butt strap, which insures the necessary strength where the drum connects with the front flitch, as large passages for circulation are provided at this point. The drum heads are bumped and fitted with a manhole at each end. The butt joints and heads are double riveted, all rivet holes drilled in place after the work is fitted, insuring fair holes and tight work.

The generating tubes are 2 inches outside diameter of extra heavy gage. The length is varied as required, depending on conditions. The down-flow tubes are 4½ inches outside diameter and No. 6 B. W. G. All tubes are expanded into the tube plates and the ends flared.

Feed water heaters and superheaters are furnished for either design when desired. As shown in Fig. 2, the feed water heater, located in the up-take, is of the long flow type, and consists of three headers with U-shaped tubes, the open ends expanded into the headers; the water entering the top header, travels through the tubes full width of the boiler four times, and is finally conducted by the internal feed pipe to the bottom of the drum, discharging through jets into the down-flow passage of the front flitch, thus increasing the circulation. The superheater is of the same general construction as the feed water heater, with a shorter flow, and is placed over the top of the down-flow tubes as shown in Fig. 2. Ample pro-

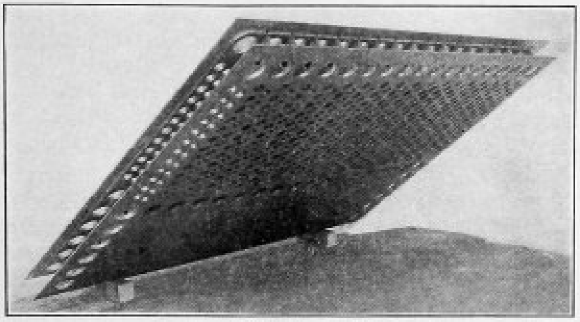


FIG. 3

vision for expansion, cleaning and renewals of the feed and superheater tubes, insures the most efficient and satisfactory results. By-pass valves are fitted on the heaters, permitting either, or both, to be cut out in case of emergency.

The casing is sectional and lined with asbestos fire felt 2 inches thick. The furnace in Fig. 1 is entirely surrounded by the large side tubes and the flitches. The furnace door openings are circular and welded into the plates. Special fire

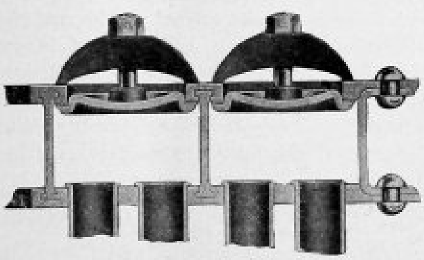


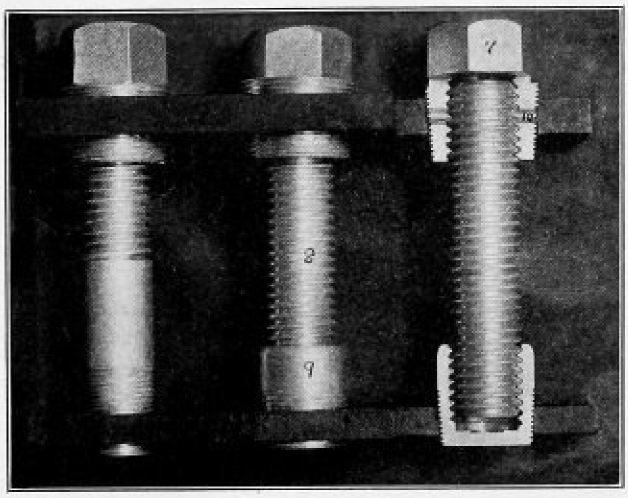
FIG. 4

brick, formed to fit around the outside of the side tubes, form the sides of the casing and are held in place by the sectional casing. In Fig. 2, the flitches do not extend below the tubes, and the furnace walls are of regular fire brick. The boiler is carried independently of the furnace walls, which can be rebuilt without disturbing either boiler or casing.

Hunter's Patent Flexible Stay Bolt

This bolt can be used as a double or single flexible bolt. When a double there are two sockets and one stud. When a single there is one socket and one stud. The leading feature in this bolt is a loose thread socket, or sockets connected together with studs. It is so arranged by the threads being cut in line with one another, that when the single bolt is used the sheets are tapped in line with one another, and when completed the stud is then screwed into inner sheet from the outside by means of a socket wrench, having a thread inside and outside. The outside thread being parallel, screws through outer sheet holding the stud in the center of the hole, at the same time acting as a dolly to rivet up the stud on the inside of the sheet. When a double flexible bolt is used the socket No. 9 is screwed into the inner sheet through the outside hole by means of a threaded stud, and is held there until riveted up, then the stud wrench is removed and the socket is ready for bolt No. 8. Socket No. 7 being attached to the stud by means of a pin, No. 10, the stud can be screwed into the inner socket at the same time that the socket No. 7 is screwed into the outer sheet.

It will be noticed that the stud has a coarse thread and a corresponding thread inside the socket, but on the outside of the socket there is a fine thread to screw into the sheet. To look at this on a drawing one would be at a loss to know how the socket could screw onto the stud at the same time as screwed into the sheet. It is arranged in this way: The threads are all seven threads to the inch. The outside, or fine



thread, is a seven-thread split, making a double thread, thus allowing a fine thread in the sheet, at the same time giving the same travel as a seven-thread. The coarse thread is where the oscillation takes place, and at the same time it gives a large wearing surface. There is a clearance allowed between the end of the stud and the inside end of the socket to allow for oscillation.

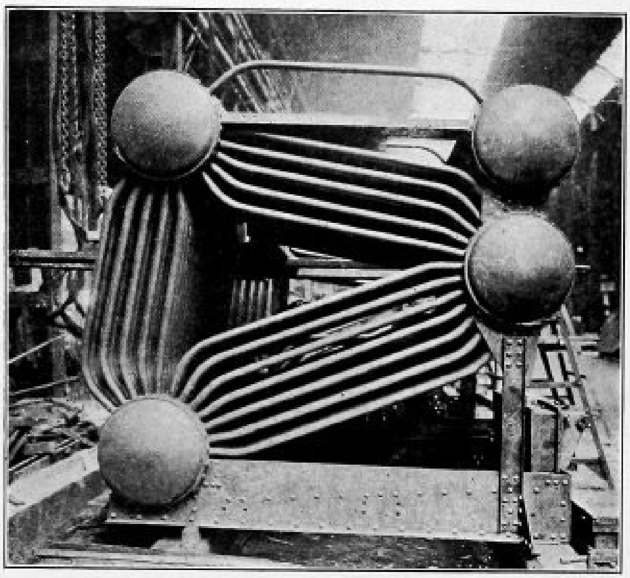
Twelve of the double flexible bolts have been in use in one of the I. C. R. locomotive boilers, in what is known as the breaking zone, for three years, and when taken out they were found to be in good condition and still having oscillation in the socket.

It has been found that these studs can be screwed into the socket and pulled apart in a testing machine, when the studs will break in the center without injury to threads in the socket or on the stud, thus demonstrating the holding power of the thread on the stay-bolt. The double flexible bolt has an advantage in that when a firebox is required to be removed, or the stay-bolts taken out from the side sheets, no cutting or breaking is necessary to get them out; all that is required is to unscrew the bolts from the inside sockets when everything is free, and the same bolts can be replaced, thus bringing about a large saving in such operations.

This stay-bolt has been patented by Mr. F. C. Hunter, Moncton, N. B.

The Badenhausen Watertube Marine Boiler

An all-steel watertube marine boiler, with no hand-hole plates, flat surfaces, stay-bolts, cast metal or screwed joints, is manufactured by the Badenhausen Boiler Company, 90 West street, New York City. The boilers are built in large units, so designed as to occupy minimum space. The arrangement consists of three or four drums connected by tubes. The large mud-drum, full of water at the point where water is most needed, means that the steaming tubes are well supplied with water under all conditions, so that the boiler can be forced to an exceptional degree. Boilers of this type, it is claimed, have been operated at 250 percent of normal rating at long



BADENHAUSEN MARINE WATERTUBE BOILER

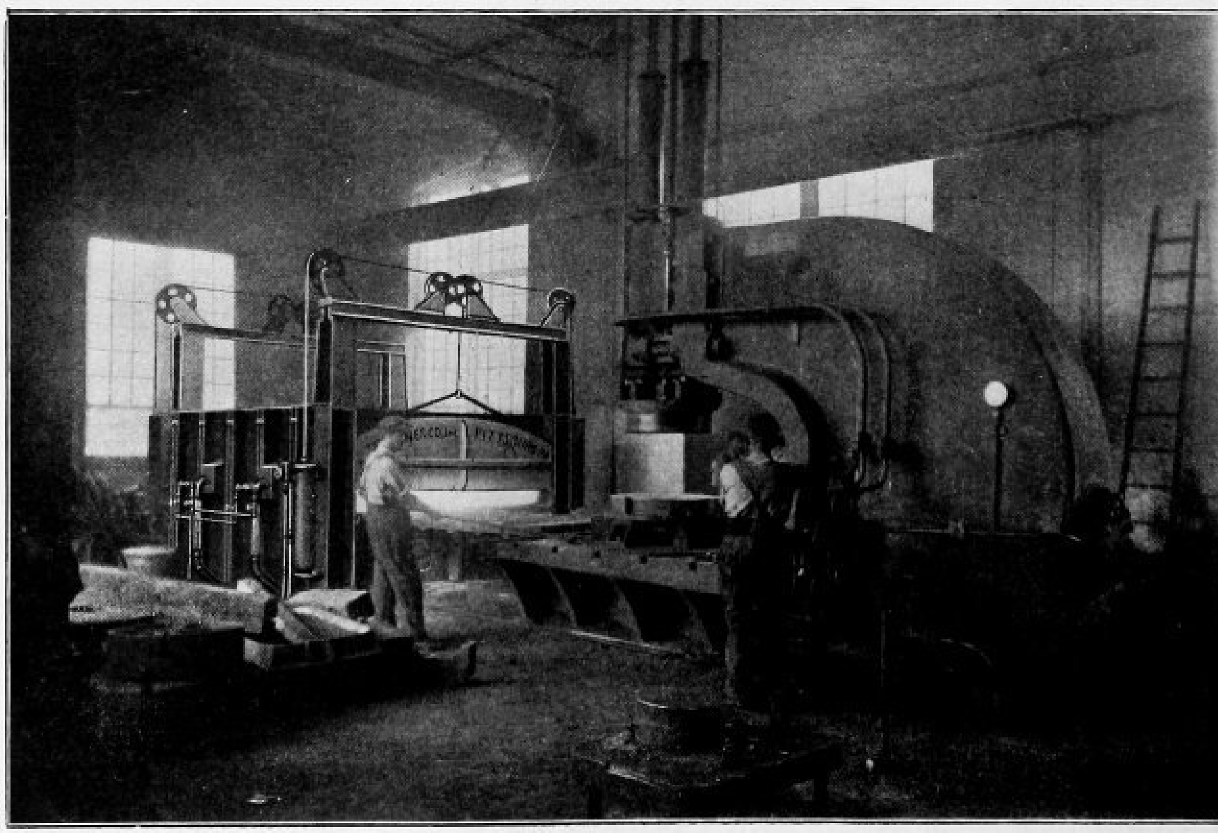
periods of time. Every tube discharges its full opening directly into the steam drum, thus delivering the mixed steam and water with the least possible disturbance. Access to the interior of the boiler is given through the drum man-holes. No hand-holes, plates, dogs, nuts or gaskets are used, so that the possibilities of leakage and failures are reduced to a minimum. The tubes are slightly bent, so as to enter the drums radially, and are cleaned by means of mechanical tube cleaners. The outside of the tubes can be cleaned from the front of the boiler by means of a steam lance. The construction of the boiler admits replacing the tubes from the front of the boiler as well as cleaning and blowing them from the same position. The baffling can also be done in a simple manner, as no special shapes are required.

Advances in steam engineering have now placed boiler design under new conditions, since it has been found that well-designed boilers can be operated economically at at least double rating, and even more, and that large units can be used to better advantage than a great number of small units. The Badenhausen boiler has been designed to meet these conditions.

New Oil-Fired Flanging Furnace

A new type of oil-fired flanging furnace has been recently installed and put in operation at the plant of the Frick Company, Waynesboro, Pa., by Tate, Jones & Company, Inc., Pittsburg, Pa. The furnace is used for heating blanks for a 200-ton sectional hydraulic flanging press. It measures 8 feet by 10 feet inside, and is equipped with the Tate-Jones system of oil burners. The air for combustion is preheated by running the air blast pipes through the flues, thus raising the air to a high temperature before it enters the furnace and increasing the efficiency of fuel utilization. Operating on 90-inch blanks the Frick Company have been getting very satisfactory results, flanging one blank every twenty minutes and using up to 15 gallons of oil per hour.

As will be seen from the illustration the furnace is arranged so that the plates may be charged at one end and drawn out at the other over a roll-table to the press. The doors are operated by pneumatic hoists, and are also counterweighted, so that they can be quickly and very easily raised and lowered. The furnace is substantially constructed of heavy cast iron and steel sections encasing firebrick walls. With the oil system used there is an absence of smoke and dirt, and the whole installation is compact and efficient in every detail. Similar Tate-Jones furnaces have been installed, and are reported giving good results at the Biggs Boiler Works, Akron, Ohio; Warren City Tank & Boiler Company, Warren, Ohio, and the Kennicott Company, Chicago Heights, Ill.



Communications of Interest from Practical Boiler Makers

Talks to Young Boiler Makers

A young man in a boiler shop asks me if I can tell him how to drive rivets. It is impossible to teach the skill of handwork by words. No amount of explanation will put the ability into fingers to play a fiddle. Words can tell you which finger is best to use on each string, and that the string must be held firmly to the neck, but practice only on a fiddle will make a good fiddler. You can be told that a rivet must be hot, but just how hot can only be determined in a boiler shop by appearance.

Of course, there are ways of determining heat. We all know that a thermometer shows it up to a certain point, and what is an equivalent to a thermometer can be used to tell the heat of a rivet, but to have such an instrument in a boiler shop is not practical. Such an instrument is called a pyrometer. There is also an instrument which shows heat by looking at the object through a glass; it is called a sight pyrometer.

This matter of heat is very interesting, and to-day it is believed that heat is a form of motion; that is, the extremely small particles called molecules, which go to make up a substance, are always in motion, and the greater the motion of these molecules the greater the heat. If they did not move at all it is believed that absolute zero would be found; but this point has never been reached. In solids these molecules are supposed to swing to and fro, while in liquids they roam all about, and in gases they move in straight lines.

The thermometer used in the United States and other English-speaking countries was made first by a Mr. Fahrenheit. He mixed salt and ice together and put a mercury bulb, such as you see in our everyday thermometer, in this mixture, and when the mercury no longer sank he marked the position on the glass, and called that zero, or the point of no heat, as he supposed. In his home in Germany, in Konigsberg or Dantzig, I am not sure which, he found that this made temperature was as cold as the coldest weather, so he concluded that as Nature produced nothing lower, and as he could produce nothing lower in his laboratory, he had reached the limit of cold. He found that at zero the volume of mercury was 11.124, and that at the point where the water froze it was 11.156, or a difference of 32, so he called the freezing point 32. When water boiled the volume of mercury expanded to 11.336 parts, or 212 parts more than at zero, so he called that point 212. He divided the space between 32 and 212 on this thermometer into 180 equal parts, and called each part a "degree." Absolute zero is believed to be —459, but has never been produced, although it is hoped that somewhere near 450 will be reached by expanding helium.

The thermometer used by "high brows" all over is called "Centigrade." It is simple, as it takes the freezing point of water and calls that zero, and the boiling point of water and calls that 100, and divides the distance between these points into 100 parts or degrees. The electrical people use this thermometer in testing their generators and motors.

If a pair of rivet tongs gets too hot to hold from being left in the fire, the reason is that the heat of the fire crawls along the handles, or, as it is called, is "conducted." Metals conduct heat much better than liquids. If we were to make a boiler out of silver it would raise steam quicker than if made out of any other metal, as this metal is the best of all conductors of heat. Why this is so is not yet known. That heat travels along a bar of steel is easy to understand, and while doing so it also gives off heat, and this giving off heat while traveling is called "radiation," and both these systems are something which can be felt, and so appeal to our minds. But a third method of heat travel is not so easy to understand; it is called "convection." It is the conveyance of heat in fluids by the motion of the particles of the fluids.

You will often hear that a boiler does not steam well on account of poor circulation. Water does not conduct or carry off heat quickly. You can have a layer of very hot water very close to a very cool one, and it will take considerable time before the temperature of the two layers will become the same if not stirred together. You can understand then that there is a great advantage in having a particle, or molecule, of water which has got hot by its contact with the hot flues moved quickly away, giving a cold particle of water a chance to get hot, and at the same time the hot particle will, in moving away from its colder mates, impart or give up some of its heat to them, and so help raise the general temperature. A good circulation of water in a boiler is therefore of great importance.

If, now, the flue gets dirty on its outside from the soot, which is made up chiefly of carbon, heat cannot pass quickly through it, as soot is a very poor conductor and the boiler steams badly. You can understand how important it is that soot should be blown off the flues when I tell you that one-hundredth of an inch of soot on a flue makes it as hard for heat to pass through it as if the boiler tube was 10 inches thick. On the inside of the flue there will be found grease and scale, the latter made up from various deposits from the water, and they are equally bad as conductors of heat as is the soot on outside. If we could only get the scale and soot on the outside of the shell of the boiler it would be an advantage, as it would prevent heat from being radiated away.

I have said that metals were good conductors, but there is one combination of metals which is not so; it is the mixture of copper, zinc and nickel in varying quantities. German silver is the usual name given to this mixture. It is quite often made with 50 parts of copper, 15.2 nickel, 3.3 tin and 31.5 zinc, but why this combination does not conduct heat well we have yet to find out.

If you pick up two bars of different metals, the one which feels the colder is the better conductor of heat. I said *feels* colder, not *is* colder, as the two bars will have the same temperature if left long enough together, but the better conductor, by carrying away the heat of your hand more rapidly, makes it *feel* to you colder. Young boiler makers, and even old ones, get mixed on this fact.

The effect of heat on water is to make it expand. One cubic inch of water when made into steam becomes 1,700 cubic inches. If you took the 1 cubic inch of water and put it in a drum which only held half of 1,700 cubic inches—that is, 850 cubic inches—and turned it into steam, the pressure developed would be twice as great, and if the drum was one-quarter the size then the pressure would be four times as great and so on. Water turns into steam at 212 degrees, and in the condition that steam is given off from water it is called "saturated steam," it may be either wet or dry. As soon as the water is turned into steam the temperature of the steam can be much more easily raised than when it was water. It takes 968 British thermal units to turn a pound of water into steam, but to raise the steam one more degree takes less than one-half a British thermal unit or, to be exact, .48 British thermal unit.

Let me say a word about this British thermal unit: When you buy gasoline or oil you order it by the gallon; it is an amount agreed upon; for heat we had to have some measure, but it could not be poured into a cup or measured with a foot rule, so it was agreed that the heat taken to raise *one* pound of water *one* degree F. would be the measure of heat, and it would be known as the British thermal unit. It is usually written B. T. U. to make it short. I have never heard anybody kick about this unit except an Irishman, and he can use the French "calorie," as it is called, which = 3.968 British thermal units, or a British thermal unit = .252 "calorie."

Steam which is superheated—that is, heated above a temperature due to the presure—contains greater energy than saturated steam; and as the energy is obtained at a comparatively small cost, engines run by superheated steam are more economical, as the great trouble with using steam economically is that it is hard to keep it hot. If it is not kept as hot as is due to the pressure it starts to turn again into water or "condenses," as it is called. Now the fact is that all the extra heat or superheat must be lost before the steam will start to condense, so there is a saving made. If you kept on superheating steam it would reach a point when it would be turned into the gases which go to make up water, that is, oxygen and hydrogen, and this point is called the "critical temperature."

I don't know where this point is; do you, Mr. Reader?

F. ORMER BOY.

Plain Talks to Apprentices in Boiler Making

This article is addressed to apprentices just starting in the boiler-making trade, and also to those who have any intention of taking it up, but who as yet are undecided what course they will follow.

If this contribution will assist any of the latter in deciding such an important question, or stimulate some who have already adopted the trade as their future occupation, the writer will be well satisfied. All I ask is that those who do not agree with me will treat this sketch with the respect they would like to have accorded their own work.

The observations are drawn from an experience extending over twenty-five years in the business, the last eleven having been spent as foreman boiler maker in the manufacture of all classes of marine and stationary boilers. While some of the statements made may be of a too candid nature, yet I have no apology to offer for their utterance.

A few words in an advisory capacity to the prospective apprentice will not, I think, be out of place.

I have seen a great many young men start in the business, without due consideration, who were not by any means adapted to it, and after two or three years have thrown up the job, resulting in that much lost time that ought to have been spent at some occupation more in harmony with their taste. Don't think for a moment that the fact of your being a boiler maker will act as a passport to exclusive society, or give you a complimentary admission to the ranks of the Four Hundred. Quite the contrary, as a great many people seem to think we occupy a very low level in the social sphere of life, and our social status should be judged accordingly. Happily this impression is not so prevalent as it was a number of years ago, and we hope will gradually disappear, the more we appreciate our position, and show others there are just as good men in our ranks as there are in those of any other industry.

To the young man who is undecided let me say: The life of a journeyman boiler maker is not made of sunshine and roses. On the contrary, about 90 percent of it is the hardest, dirtiest and most laborious of any in the mechanical lines, but if you are not afraid of hard work and have the right kind of stuff in you to get to the top there is something worth while ahead. For the young man in the trade who is ambitious the future looks bright indeed, as nearly all countries are recognizing the value and importance of steam boiler inspection and are enacting legislation compelling all users of steam to have these boilers inspected annually, thereby opening up a new field, and creating positions for men who can qualify after a strict examination. Some States make it imperative that candidates for such positions must be practical boiler makers of at least ten years' experience. This is as it should be, as the practical boiler maker is better able to pass judgment on a weak boiler than an engineer who has never nad experience in their manufacture. I hope the day is not far distant when all boiler inspectors shall be practical boiler makers, thereby giving the men who have adopted the calling as their life work a chance to enjoy some of the positions now held by engineers, who, as a rule, are not fairly entitled to hold such positions.

Now for the apprentice in the shop who is desirous of getting along. My advice to him is to take lessons in mechanical drawing, a privilege that almost all Young Men's Christian Associations offer for a small fee, where one gets acquainted with the essential geometrical problems necessary to the laying out of boiler work. Get a set of simple drawing instruments, a standard scale, a drawing board and a few books on laying out. I might mention two of the best, in my opinion, *The Practical Boilermaker* and John Nichol's work, or any other of the numerous works to be had. Start out with the simpler problems, an ordinary cone for example. Work it out on paper to a scale exactly as it would be full size, then cut it out with a pair of scissors, put it together with mucilage or common paste. You can then judge for yourself whether you have worked it out properly or not.

I have often been surprised at the attitude of some boys in the shop in regard to the foreman and one or more of their fellow apprentices. I refer to the impression that prevails among apprentices when they think one of their number is too intimate with the boss. He is put down as a dub, looking for a pull in order only to serve his own ends. Now this is decidedly wrong and unfair, as any boy can take an interest in his work, do many things to assist the boss, and at the same time himself, without being put down in the category of a sucker. No boy ought to care what his shopmates think about him if he is satisfied in his own mind he is right, that being a question for his conscience to decide. Many an opportunity is lost to some boy who considers others would criticise him adversely.

No boy should stay in a shop after getting through his time. Strike out among different shops in order to get a varied experience and more appreciation, likewise better wages, and if you are steady and have ability there is no doubt you will advance and prosper in the boiler making trade.

J. T. BRADBURY.

How Do the Others Feel About It?

As I am a subscriber and an occasional contributor to your valued publication, I naturally feel interested in all, or at least the majority, of articles which appear from time to time. The February issue is particularly interesting from beginning to end, and comparing it with one published a few years ago one cannot help noticing the improvement that has taken place. The "Communications of Interest" department is bright and rivets the attention at once. By all means keep it going, and if it swells, let it.

Mr. Hobart's article on the application of geometry to practical work is not only valuable to boiler makers but to other craftsmen as well. I trust he may be induced to continue with that subject. Incidentally I might say that others besides boiler makers read your paper with a great deal of interest, and look for it month after month. Keep the good work "agoing," and may success always attend you.

CHARLES J. MASON.

How to Lay Out a Tapered Course

In answer to the query on page 22 of the January issue of THE BOILER MAKER, regarding the proper method of laying out a tapered course, I submit the following:

The rule I have always used, and the one I have found correct, is: Suppose you have a stack 30 inches in diameter to make out of ¼-inch plate. Now for the large end I add the thickness of the plate to the given diameter, which makes 30¼ inches; for the small end I deduct ¼ inch from the given diameter, which makes 29¾ inches. Thus 30¼ × 3.1416 = 95 inches = 7 feet 11 inches circumference of large end, and 29¾ × 3.1416 = 93½ inches = 7 feet 9½ inches circumference of small end.

As regards the right method for ascertaining the circumference for angle-iron ring, I do not believe there is any exact rule for same. In fact, I fail to see just how there could be any rule that would work out exact in all cases, and the reason is that a ring that one mechanic would make from a bar 6 feet long, using a short fire, and a ring another mechanic would make, using a long fire and taking long heats, would differ greatly in diameter.

A rule I have found to work as nearly correct as any is as follows:

Supposing you have a ring 60 inches in diameter to make of 3-inch by 3-inch by ½-inch angle iron, flange outside. 60 × 3.1416 = 188½ inches = 15 feet 8½ inches.

To this add twice the width of your bar, which is 6 inches, making a total of 16 feet 2½ inches.

Take your bar and cut it to this length, then mark it with a center punch exactly in the middle.

Next lay out your ring, full size, on a plate or block, and strike a line across its center.

Bend one-half of your bar according to the circle laid out on your plate, and by placing the end of your bar on the line that bisects your circle you will see on the opposite side how near the center your punch mark comes. If it is 1 inch over the line towards the straight end of your bar it is proof that the bar is 2 inches too long, and you must cut that amount before bending the other half.

If you want to make an angle-iron ring with flange inside get the length as before, but instead of adding twice the width of the bar deduct once the width of the bar from the length and proceed as before. W. A. GUIHAN.

Truro, N. S.

Useful Rules and Formulas

In sorting over my old papers and books, I came across a lot of old memorandum books, some I have had for fifty years or over, with rules and formulas I used when I first took charge of boiler shops. Possibly some of the readers may be interested, so I herewith submit a few of them.

First on the list is the old rule to compute the pressure for a given thickness of plate in inches and diameter of boiler:

Multiply the thickness of plate in inches by one-sixth of tensile strength and divide by radius of boiler in inches; or, to get thickness of plate, multiply pressure wanted by radius of boiler and divide by one-sixth of tensile strength of plate. To get the resistance of plate to crushing, let *d* equal diameter of rivet to equal thickness of plate and 40 tons the tensile strength (40,000 to 45,000 pounds was the tensile strength of shell plate in those days). Solution:

.375 × .75 × 80,000 = 22,500, + resistance to crushing.

Resistance to shearing of rivets is calculated at 20 tons per square inch, hence: .75 × .75 ×.7854 = .44179 and .44179 × 40,000 = 17,671.6 ÷ 2,000 = 8 tons and 1,671 pounds over.

Strength of plate between rivet holes:

Single lap may be taken at 20 tons, 40,000 pounds per square inch.

Whereas, resistance of plate = $t\ (p - d) \times 40{,}000$.

Calling pitch of rivets 2 inches, we get 2 — .75 = 1.25; 1.25 × .375 = .46875; .46875 × 40,000 = 18,750, or 9 tons and 750 pounds over. So we see that the plate is stronger than the rivets; but by spacing the rivets 1⅞-inch centers the plate and rivets would be about equal.

To get the distance between centers of rivets, divide the area of rivets by thickness of plate and add the diameter of rivet. The area of ¾-inch rivets, .44179 ÷ .375 = 1.17; 1.17 + .75 = 1.92, or say 1⅞ inches center. For double riveting take twice the area of rivet and divide by thickness of plate and add two-thirds the diameter of rivet. The product will be the pitch required. Thus, .44179 × 2 = .88358; .88358 ÷ .375 = 2.356; 2.356 + .50 = 2.856, or call it 2⅞-inch centers.

The next to be figured is the area above tubes to be braced. This we get by drawing the line or chord across the top of the tubes as shown at *E F*, and from these points draw chords of half the arc as shown at *E g* and *F g*. Divide one

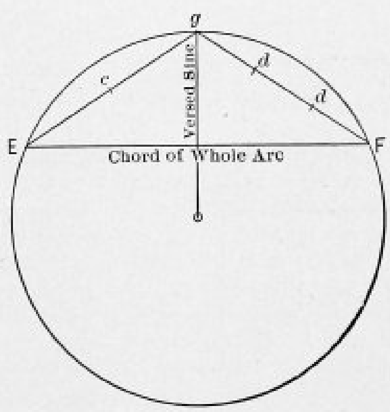


DIAGRAM FOR FINDING AREA OF SEGMENT

of these lines into three spaces, as shown at *d d*. Then to the chord of the whole arc *E F* add the chord of half the arc *E c* and one-third of it more *F d*. Multiply this by the versed sine and this product by the decimals .40426, which will give the area nearly. Or, put the two triangles together to form a rectangle and get the area by multiplying the length by the breadth. Add the two arcs *E g* and *F g* together to form an eclipse; add the length and breadth together and divide by 2 and multiply that product by the decimals .7854. Add the two areas of the rectangle and elipse together and that will give the area to be braced. To find the number of braces multiply the area by the pressure and divide by 5,000 and the number will be found.

The next, if we are getting out a firebox boiler, would be to find the distances to space staybolts. The constant up to and including 7/16-inch plate was 95. Multiply the thickness of plate squared by 95 and divide by the pressure required. If the plate was, say, ⅜ inch, then, as there are 6/16 in ⅜, 6 × 6 = 36; 36 × 95 = 3,420; 3,420 ÷ 125 = 27.36. The square root of 27.36 is 5.23, or say 5¼-inch centers.

Springfield, Ill. JOHN COOK.

Pure tin makes the best filling for the fusible plugs of steam boilers, alloys being objectionable, because those that have been tried for the purpose appear to undergo a gradual change when exposed continuously to heat, so that their melting points do not remain constant. The melting point of tin averages 449.2 degrees F. A tin-filled plug will not melt out from the natural heat of the steam until the pressure of the steam becomes 363.3 pounds per square inches.

Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

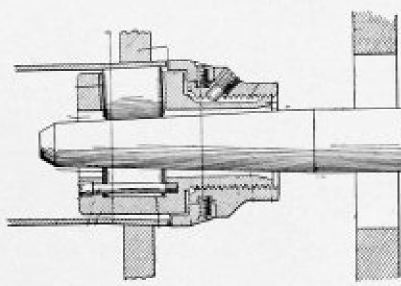
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,006,898. WATER-LEVEL ALARM FOR BOILERS. LEWIS BEEBEE, OF SAGINAW, MICH.

Claim 1.—The combination with a receptacle containing a liquid and a gaseous fluid under pressure, a pipe extending into the receptacle to communicate with the gaseous fluid space thereof and forming a support, a float-carrying arm arranged within the receptacle, means within the receptacle for mounting the arm wholly on the support, a whistle actuated by gaseous fluid escaping through the pipe or support, and operating means between the said arm and whistle. Ten claims.

1,007,017. BOILER-TUBE EXPANDER. OTTO H. WIEDEKE, OF DAYTON, OHIO.

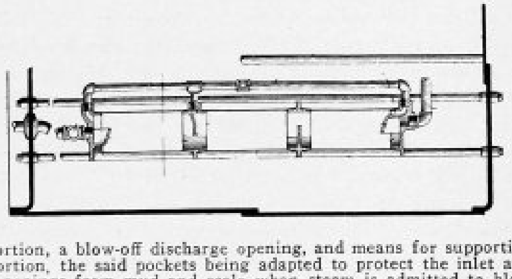
Claim 2.—In a device of the type specified, a roller cage having a mandrel and a series of roller pockets, rollers in said pockets, and a detachable pin arranged adjacent to the inner terminal of each pocket and



reducing the diameter of such parts of said pockets, whereby means are provided for preventing the rollers from becoming displaced, or permitting of their removal. Three claims.

1,006,479. FEED-WATED HEATING AND PURIFYING APPARATUS. FREDERICK M. HARMON, OF CLEVELAND, OHIO.

Claim 1.—A feed-water purifier comprising in combination, a body portion, an inlet opening, an outlet opening, pockets on the inside of the body portion adjacent each opening, means for admitting steam into the



body portion, a blow-off discharge opening, and means for supporting the body portion, the said pockets being adapted to protect the inlet and the outlet openings from mud and scale when steam is admitted to blow out the body portion. Sixteen claims.

1,003,059. STEAM BOILER. JOHN THOMAS NICOLSON, OF MARPLE, ENGLAND.

Claim 1.—In steam generators, in combination, two water drums, a nest of water tubes connecting said water drums, an inclosing flue around said nest of tubes, an interception drum or chamber out of the path of the hot gases, a water conduit between one of said drums and said interception chamber, a further water drum, a water conduit between the latter and said interception chamber, a steam-and-water drum, a nest of tubes connecting said steam-and-water drum with said further water drum, and an inclosing flue around the latter nest of tubes. Six claims.

1,007,175. SAFETY DEVICE FOR STEAM BOILERS. JOHN J. BARRY AND FRANCIS L. STREET, OF NEODESHA, KAN.

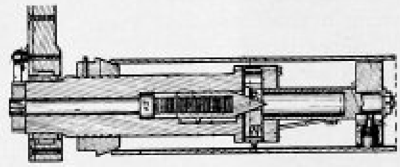
Claim 2.—In a device of the class described, a casing, a steam supply pipe opening into the casing, a steam discharge pipe leading from the casing, a fusible plug fitted in the casing and closing communication between the steam supply and discharge pipes, and a vent pipe leading from the casing at a point immediately above the upper end of the plug. Seven claims.

1,007,329. BOILER. JOHANN GEORGE BRIEGEL, OF PHILADELPHIA, PA., ASSIGNOR OF ONE-THIRD TO WILLIAM H. OSWALD AND ONE-THIRD TO GEORGE F. WIELAND, BOTH OF LINDSAY, CAL.

Claim.—In a watertube boiler, an outer casing comprising a lower section suitably supported and provided with an annular angle iron secured to the upper portion thereof, an upper casing section having an annular angle iron secured to said angle iron, an angle plate secured to the upper inner portion of said casing section and adapted to project inwardly, an inner watertube supporting shell having its lower portion secured to the lower portion of the casing section by suitable fastening devices, a water-retaining chamber secured in the lower portion of said inner shell and projecting laterally and inwardly therefrom, the upper portion of said water-retaining chamber extending above the line of junction between said sections, a series of horizontal watertubes arranged transversely and having their ends secured in said inner shell, a stack secured to said inner shell and projecting upwardly through and beyond said angle plate and in water-tight juxtaposition therewith, a series of laterally-elongated apertures in the said outer section arranged alternately in alinement with the laterally-exending watertubes and adapted to receive suitable closures, and elongated reinforcing plates riveted to said outer section, said laterally-elongated openings and plates extending partially around said upper section and being arranged in staggered order vertically so as to permit of access to all of the alternate ends of said juxtaposed transverse watertubes in the same plane as said elongated opening, said lower section being adapted to have trunnions secured thereto and projecting outwardly therefrom at a point beyond the central axis of the boiler.

1,007,330. BOILER-TUBE CUTTER. JACK L. BROWDER, OF OTTUMWA, IA.

Claim 2.—In a boiler-tube cutter, the combination of a body portion designed to be inserted in a boiler tube, a series of radially movable cutter arms pivotally mounted in the body portion capable of movement in a plane at right angles to the longitudinal axis of said body portion, means for exerting yielding pressure on said cutting arms to normally



draw them inwardly toward the center of said body portion, roller cutters mounted in said arms adjacent to a boiler tube, an adjustable collar on the body portion designed to partially enter the end portion of a boiler tube and to center the body portion within the boiler tube, an extension on the inner end of said body portion, a disk carried by said extension, and spring actuated guide devices normally projected outwardly from the disk to yieldingly engage the interior of a boiler tube. Four claims.

1,007,528. STEAM-BOILER FURNACE. ELMER E. CARR, OF CHICAGO, ILL.

Claim 2.—In combination, a steam boiler furnace having a fire grate, and an arch extending over the grate supported at its sides and at one end only and the upper side of the arch being exposed to air from without the furnace, the said arch being formed of brick arranged in longitudinal rows with interstices between adjacent bricks in the same row extending over a part of the arch only, the remainder of the arch being closed, the said interstices constituting air passages through the arch and being segregated in a part of the arch of substantially pyramidal form, the axis of the pyramid being coincident with the longitudinal median line of the arch and the base of the pyramid being adjacent the unsupported end of the arch. Two claims.

1,008,515. STEAM GENERATOR. ALBERT L. AUSTIN, OF LAKEWOOD, OHIO.

Claim 1.—In a device of the character described, the combination of a water chamber, pipes depending from said chamber and bent upwardly at the lower ends, a tube inclosing the upwardly extending portions of said pipes, and a hot blast directed into the bottom of said tube and arranged so that the descending portions of said pipes are subjected to substantially no heat and so that substantially the full force of said blast is applied to said pipes at the points where they are bent upwardly. Seven claims.

1,008,526. WATERTUBE BOILER. GEORGE COOK, OF BUFFALO, N. Y.

Claim 1.—In a watertube boiler, the combination with upright inner and outer shells separated by a water space, a fire-box at the bottom of the inner shell and a smoke pipe at the upper end of said inner shell, of a cast metal water circulating frame arranged transversely in the inner shell between said fire-box and said smoke pipe and in communication with said water space, a tube for introducing steam or water to the exterior of said circulating frame and the interior of the inner shell to cleanse both, said tube connecting said outer shell with said inner shell and positioned in a plane beneath said smoke pipe and means for closing the outer end of said tube. Two claims.

1,008,638. INDUCED-DRAFT AND SMOKE CONSUMER. DANIEL GOFF, OF MILLVILLE, N. J.

Claim 1.—In a device of the character stated, a fire-box, a boiler, a steam chamber having ports for directing the steam therefrom into said fire-box, a jacket around said steam chamber forming chambers having communication with each other, a pipe leading from said boiler to one of the chambers in the jacket, a pipe leading from the other chamber in the jacket, a steam valve chamber into which the last-mentioned pipe discharges, a valve controlling said valve steam chamber, a pipe leading from said valve steam chamber and communicating with said steam chamber, and means for actuating said valve by steam from the boiler whereby the flow of steam through said steam valve chamber is permitted. Six claims.

1,009,665. TRAVELING GRATE. CALEB M. EAST, OF DETROIT, MICH., ASSIGNOR TO MURPHY IRON WORKS, OF DETROIT, MICH., A CORPORATION OF MICHIGAN.

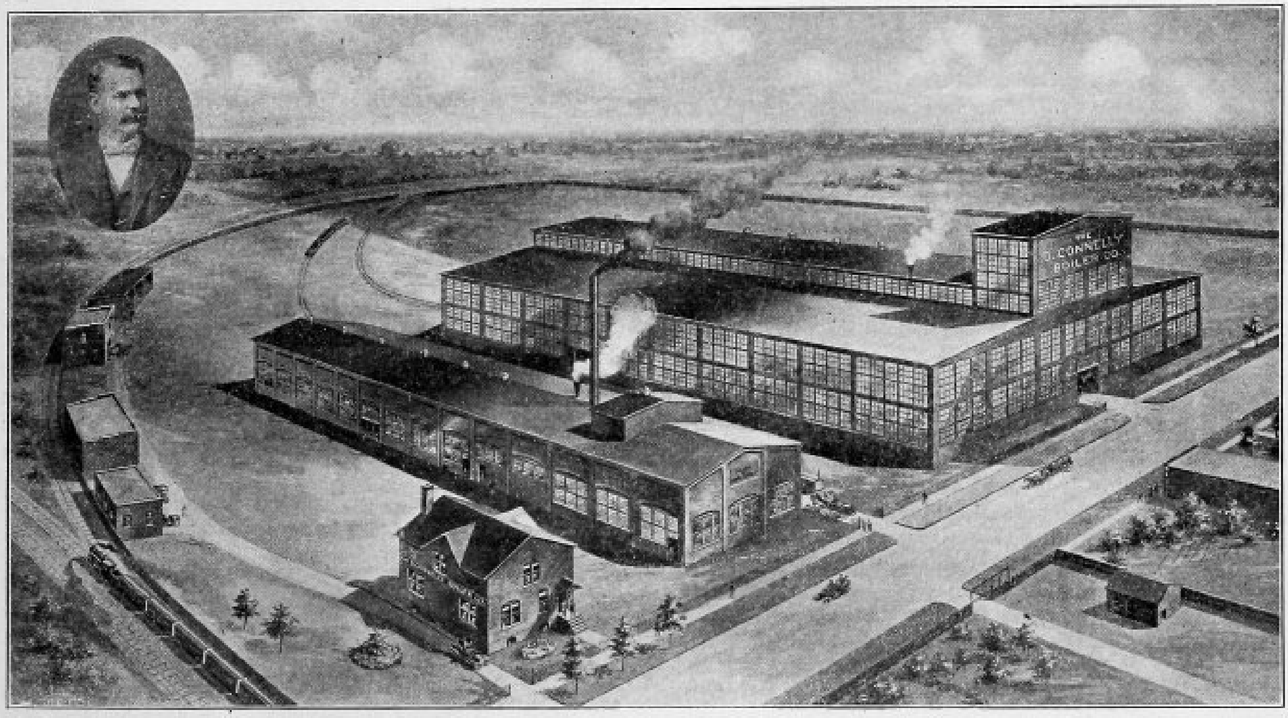
Claim 1.—In combination with a furnace wall, a longitudinally-movable grate structure, a member on said structure adjacent to the margin thereof projecting above the plane of the grate surface and movable with said structure adjacent to the furnace wall to cleave from said wall residue of fuel adhering thereto. Ten claims.

The Boiler Maker

APRIL, 1912

A Modern Plant for the Manufacture of Boilers and Heavy Steel Plate Work

One of the most modern plants in the United States for the manufacture of boilers and heavy plate work is the plant of The D. Connelly Boiler Company at Cleveland, Ohio. This business was established in 1875 by the late Daniel Connelly, who was one of the best-known boiler manufacturers of the Middle West, and the new plant was designed and built entirely to conform to his ideas. The new plant was completed and put in operation on Feb. 14, 1911, and the death of the founder occurred eleven days later, so that he never lived to see the first job leave the plant.



A MODERN BOILER SHOP

This plant is located on a plot of 6 acres situated on the main line of the New York Central & St. Louis Railway, having a frontage of 558 feet on Ivanhoe road, formerly East Collamer street, and a depth of 590 feet on the north line, which gradually tapers off to a depth of about 300 feet on the south line. This site is located about seven miles from the public square, in the city of Cleveland, and is reached by two direct street car lines. The Euclid avenue line is only one-fifth of a mile and the St. Clair avenue line is one-third of a mile from the plant. The rate of fare from any part of the city is three cents.

Mr. Connelly in designing the plant has planned for the development of all buildings without any undue cost or expense. There are two main railroad spurs into the property, one going into the main building, known as the boiler shop; the other goes in along the side of the power house and forge shop.

Boiler Shop

The main building is 140 feet wide and 188 feet long, and is divided into three isles or bays. Each side bay is 40 feet wide and 35 feet high, and the structure is designed to carry a load of 15 tons on the cranes. The center bay is 60 feet wide by 47 feet high, and the structure is designed to lift a 40-ton load at any place in the bay. The columns are spaced 40 feet centers longitudinally, which is probably a greater distance than is used in any other boiler shop in the United States, where the capacity is figured for a 40-ton lift, but the owner wanted to provide for the handling of long plates at the punches and other tools.

At the front or street end of the center bay is a riveting tower which extends the full width of the bay (60 feet), providing space for three hydraulic riveters, and this tower has a carrying capacity of 60 tons, or a 20-ton load over each riveter, all at the same time. The distance from the floor to the crane runway in the tower is 60 feet, which is also exceptional, the owner planning to provide so that a 35-foot tank could be riveted on an 18-foot 6-inch riveter.

The sides of this building are brick for the lower 5 feet, everything above this being "factory rib" glass on all four sides. The interior of the shop is, therefore, as light as out-of-doors. All doorways are 12 feet by 16 feet high, except the rear door, where the track enters the shop, this being a steel rolling door, and the opening is 16 feet wide by 20 feet high. The side bays of this building have a 2-inch oak floor laid on oak stringers which were well creosoted. The center bay or erecting floor is paved with paving brick having three catch basins in same, which all connect with the sewer. The railroad track enters the rear of this building in the center bay, but close to the row of columns, and the track extends 90 feet inside of building. On each side bay there is at present one 10-ton electric traveler operated from the floor; on the center bay is a 25-ton electric traveler operated by a crane man on the machine.

In the south bay, backing up to the side wall, are two quick-acting punches with 36-inch throat, capacity up to 7/8 inch material, and a heavy duty punch, 48-inch throat, capacity 4-inch hole in 1-inch plate, also a flange punch, Wangler bevel shear, and a set of rolls 12 feet 2 inches between housings for rolling 1⅛-inch plate. The entire line of shaft on this side of the building is operated by a 30-horsepower motor, located at the front end of the building. Each tool has its individual jib crane of three tons capacity, equipped with a three-ton air hoist. The rolls are equipped with a pair of engines. All material from ¼ inch up are worked upon this side of the shop.

In the other bay are two quick-acting horizontal punches, a Lennox bevel shear, bending rolls 8 feet between housings, a radial drill with 5-foot arm and another with a 4-foot arm. At the front end of this bay, partitioned off with a wire fence, is a tool room which contains two lathes, a drill press, bolt cutter and emery grinder, besides cupboards and benches for care of small tools. There are two other emery grinders in this building, one on each side of the shop at about the center of the building. The line shaft on the north side of the building is also driven by a 25-horsepower motor, located in the tool room. Each tool on this side of the shop has an individual jib crane of 1½ tons capacity, with air hoist.

The toilet is a one story building attached to the south side of this building, and contains six washdown closets, white enamel, urinal, both with automatic flush, also white enamel wash sink with hot and cold water.

About 40 feet in the rear of the boiler shop, and located close to the railroad track that enters the building, is a portable building about 20 feet by 30 feet, which is used as a store-room for all paints and rivets.

Power House and Forge

This building is situated 50 feet away from the boiler shop, running parallel with it, and is 50 feet wide by 200 feet long, built entirely of brick and steel, with large windows. The front end of this building is the engine room, and is 40 feet by 50 feet, containing a 75-kilowatts Ridgeway engine and dynamo, direct connected; also a compound Franklin steam-driven air compressor, furnishing 1,000 cubic feet of air per minute, Barr steam-driven hydraulic pumps, and the hydraulic accumulator. Here, again, the owner provided for expansion, as the equipment is so placed that a duplicate of each machine can be added without rearrangement of the room. The steam and hydraulic lines pass to the boiler shop through a cement trench below the grade, and covered over with heavy C. I. plates, so that by removing them the pipes can be reached in an instant The bottom of the trench is cemented, tapered and connected to the sewer, so as to be dry at all times.

The boiler room is next and is also 40 feet by 50 feet. It contains two tubular boilers 78 inches by 18 feet, built for 125 pounds working pressure. Provision has also been made for a third boiler. Coal is unloaded from the car directly in front of the boiler, and there is storage space inside the boiler room for two cars of coal. The boiler room also contains a feed water heater and the feed pumps.

The balance of this building, which is 50 feet by 120 feet, is the blacksmith and forge shop. This room contains a 150 ton universal hydraulic flanging press, a spinning machine for flanging heads up to ¾-inch by 96-inch diameter, an 800-pound steam hammer, an annealing furnace having an oven 11 feet by 16 feet which is heated with fuel oil, a flue welding machine, a saw for cutting off flues hot, two hand-flange fires, and two other blacksmith fires. About 300 feet in the rear of the forge shop, and close to the railroad spur, a storage tank of 10,000 gallons capacity is buried for storing the fuel oil. This is filled from car tanks by gravity, and the oil is pumped to a smaller supply tank situated in the rear of the forge shop by a motor driven pump located inside the forge shop at the rear wall.

The rear wall of the boiler shop is made up of matched wooden sections covered with corrugated steel on the outside, so that the same can be removed to extend the building and used again. The rear wall of the forge shop is hollow tile, and the fire wall between the forge and boiler room and between the boiler room and engine room are also tile. In the rear of the forge shop is a motor driven tumbling mill for cleaning boiler flues.

Office Building

The office building, situated 50 feet south of the power house, is a brick building 32 feet by 32 feet, two stories high, with a basement under the whole building. In the basement is a fireproof vault 5 feet by 8 feet inside and fitted with double steel burglar and fireproof doors, also a furnace room 16 feet by 16 feet, and a storeroom 16 feet by 16 feet, all equipped with shelves for storing old files, books and records. On the first floor of the office is the combined vestibule and waiting room, about 5 feet by 8 feet, partitioned off from the office, with walls which are all glass from 5 feet above the floor to the ceiling. The general office is about 16 feet by 25 feet, and at the rear is an entrace to the yard and basement, and also stairs to the second floor, and a fire-proof vault 5 feet by 8 feet, which is attached to the building. There is a coat room 5 feet by 6 feet off the main office. The front private office is 15 feet by 18 feet, and the rear private office is 15 feet by 12 feet. Each office has four extra large windows, giving perfect light and ventilation. The entire second floor is one large room for use as a drafting room. A laboratory is also partitioned off on the second floor.

The first building to the rear and south of the office is the garage for private automobiles. The next building is a two-story pattern storeroom, 30 feet by 40 feet, well equipped with shelves for storing patterns in an orderly and systematic manner. The only windows and doors in this building are on the north side or away from the railroad, and the windows have metal shutters. The doors are covered with steel, and all windows have wire glass. The west hall has an archway on both floors, to provide for an addition to the building. The next building is the stable, and the last building is the wagon shed.

General

The boiler shop is lighted artificially by ten Adams-Bagnell flaming arc lamps, each 2,400-candlepower capacity, five being placed on each side of the shop, hung under the craneways of the main bay. The blacksmith shop has three carbon arc lights, the engine room and boiler room each have one arc and several incandescent lights. In the boiler shop are two 75-foot reels of 2-inch hose with nozzle, and eight non-freezing fire extinguishers. The boiler room also has a reel of hose, and there are four fire extinguishers in this building. The office, garage and stable each have a fire extinguisher, and the pattern storeroom has one on each floor. The street in front of the shop is paved with paving brick, there are two double fire plugs in front of the property, also a fire alarm box and a complete fire department within a mile.

The plant stands as a monument to Daniel Connelly, who worked out every detail in connection with the building of it, and the business is being conducted by his two sons, who were associated with him for more than ten years, and to whom he gave a very thorough training in the business.

Twenty-Fourth Annual Convention of the American Boiler Manufacturers' Association

The twenty-fourth annual convention of the American Boiler Manufacturers' Association, held at New Orleans on March 12, 13 and 14, was well up to the improved standard established of more recent years by the younger element, who have determined to push the campaign for membership so that this association, which has long been doing yeoman service for the trade at large, may attract to it its share of membership from the boiler manufacturers of the entire country, without whose co-operation no great work can be accomplished in the way of needed legislation. Under the presidency of Col. E. D. Meier, of New York City, the meetings have latterly taken on a more technical character, and the present meeting provided more than the usual number of addresses on technical subjects, all of which were given full attention and appreciation.

TUESDAY MORNING SESSION

The first session, opening on Tuesday morning, March 12, was called to order by Secretary Farasey in the temporary absence of the president, whose train was delayed but who arrived shortly thereafter. Mr. Farsay introduced the second vice-president, Mr. J. Don Smith, of Charleston, S. C., as First Vice-President Rees' train was also delayed, a common occurrence in the South this season, owing to the excessively heavy rains in that region which have made it dangerous for railroads to attempt to make up time.

Mr. Smith introduced Mayor Behrman, a ready and resourceful speaker, who not only extended a welcome of the warmest character but gave the visitors some idea of the progress that New Orleans is making in forging ahead to hold her position in the New South, in order to be ready for the opening of the Panama Canal with its immense trade possibilities for this harbor.

Mr. Bateman responded to the Mayor in his usual pleasing manner, pointing out that many other communities might well follow the example of New Orleans, with her publicly-owned docks and wharves and belt line railroad switching service for shippers. He paid a high tribute to the character of New Orleans hospitality.

Mr. John H. Murphy, of the Local Entertainment Committee, and Mr. James W. Porch, president of the New Orleans Progressive Union, gave addresses of welcome to the association, which were responded to by Col. Meier upon his arrival. Mr. F. B. Slocum, of the Supply Men's Association, then announced the various entertainment functions of the week, also mentioning the fact of the great mass meeting to be held in the evening under the auspices of the American Cane Growers' Association to protest against the removal of the tariff on sugar. Secretary Farasey read a telegram from Past President Richard Hammond, of Buffalo, N. Y., urging the immediate and pressing importance of the movement for standard specifications for construction of all types of steam boilers and other pressure vessels, and care of same in service; also voicing his regret at being unable to attend the convention.

Col. Meier then went on to recount the history of the efforts of the American Boiler Manufacturers' Association towards uniformity of practice and specifications, which points were afterwards covered largely in the report of the Committee on Uniform Boiler Specifications made at this convention later in their sessions. Capt. Cotter, of the 10th District of the Steamboat Inspection Service, was introduced as the representative of Gen. George Uhler, Supervising Inspector-General of the Steamboat Inspection Service, and after his address an adjournment was taken until the afternoon.

TUESDAY AFTERNOON SESSION

Immediately on the opening of the afternoon session President Meier appointed the following convention committees: Nomination—G. N. Riley, M. G. Weidner, L. E. Connelly; Auditing—G. N. Riley, J. Don Smith; Place of Next Meeting—Chas. Wangler, J. J. Finnigan, R. Munroe; Uniform Specifications—E. D. Meier, H. J. Hartley, A. J. Schaaf, T. M. Rees, B. Scannell, Sr., H. C. Meinholtz, C. F. Koopman, Jr.

The following invitation and communications relative to convention cities were received: Carl Dehoney, Cincinnati Commercial Association; E. V. Parrish, manager Commercial Club, Omaha; Thos. L. Cannon, secretary-manager St. Louis Convention Bureau; Goodman King, vice-president same; Governor Hadley, of Missouri; Hon. F. H. Kreisman, Mayor St. Louis. Also from Mayor James C. Dahlman, Mayor of Omaha, through Mr. Riley.

An invitation to hold the next convention in Cleveland was tendered by Secretary Farasey, with the suggestion that it was a central point and that every attention possible would be accorded the convention should it decide to come to Cleveland.

Mr. William P. Luck, representing the Erie City Iron Works, presented an invitation from Erie, Pa., with the offer to entertain the convention without cost to it. The various invitations were duly referred to the Committee on Time and Place. Mr. Luck asked and was given privilege of submitting to the Committee on Specifications certain suggestions from the Erie City Iron Works people, which were not read in convention but duly considered by the committee.

Opposition to Free Sugar

Mr. Champion brought up the matter of complaint from the Southern people, especially of Louisiana, as to taking sugar into the free list, and asked that Mr. Luck be given the floor to present certain resolutions pertaining to same. Mr. Champion thought that the Southern manufacturers should be recognized in this matter, inasmuch as their interests were largely inter-dependent with the sugar manufacturers. President Meier said he believed it was very ill-timed, to now ask to have sugar alone of all the many protected articles suddenly put on the free list was very drastic, to say the least. No matter how we feel as to free sugar, this is not the time for such drastic action. If any change is made in the tariff it should be made with the utmost care, considering all the interests involved and with due warning to invested capital.

Mr. Luck being given the floor, apologized for his shortcomings as an orator and made as strong a speech as he could in favor of the resolutions he presented. He stated that the investment in sugar manufacture in the State of Louisiana represented two hundred million dollars and in the States west over three hundred million. An effort was now being made to rush the repeal of the duty through Congress without even giving the large interests concerned a due hearing. It is absolutely impossible for sugar to be produced in this country in free and unprotected competition with Germany and other nations, even Japan. The exact measure of the necessary protection is a mooted question, which should have a fair hearing in Congress. The investment in the Southern and Southwestern States represents from three to five hundred million dollars exclusive of Louisiana. Aside from any partisanship, the question should receive fair treatment and justice accorded all interests. As representing the American Cane Growers' Association, Mr. Luck moved the adoption of the resolutions, which carried unanimously, after a strong speech from Mr. Porch favoring the same, in which Mr. Thos. Rees, of Pittsburg, concurred, and also Mr. Corbett.

Following the adoption of the foregoing Mr. Slocum moved that Mr. Porch be made a committee of one to prepare a suitable telegram to the Representatives in Congress, advising of the action taken, and Mr. Porch drafted the following and read the same upon request, whereupon it was unanimously ratified by the convention:

"To Hon. Joseph E. Ransdell and Hon. Robert Broussard, H. R., Washington, D. C.—The twenty-fourth annual convention of the American Boiler Manufacturers' Association and of the Supplymen's Association, an adjunct of the first named, representing hundreds of millions of invested capital, to-day in joint meeting assembled unanimously adopted strong resolutions protesting in forceful language against the high-handed methods adopted by the Ways and Means Committee of Congress, and which now threatens to be approved by the House, with reference to the free entry of sugar into the United States, which will mean confiscation of from three hundred to five hundred million dollars of vested rights, and which will utterly destroy the sugar industry of Louisiana and Texas, as well as the best sugar interests of the North and West. We submit that this is un-American, neither Democratic nor Republican, and directly opposed to our American institutions, and the bill should be defeated. We condemn such star chamber proceedings and demand that a public matter of the importance of this should be decided upon only after a full and free hearing has first been had. E. D. Meier, President."

Rivets

Mr. David J. Champion, of the Champion Rivet Co., Cleveland, Ohio, read a paper on "Rivets."*

Hydraulic Riveting

Mr. H. J. Hartley, of the Cramp Ship Building Co., Philadelphia, read a paper on "Hydraulic Riveting."* In connection with this paper Mr. Hartley exhibited a number of blue prints, which, on motion of Mr. Bateman, it was voted to include in the proceedings of this convention.

* An abstract of this paper is printed on page 123.
† An abstract of this paper is printed on page 114.

The convention now adjourned until ten o'clock Wednesday morning. The remainder of the afternoon the Committee on Uniform Boiler Specifications was in session, as also on the morning of the day following and afternoon, and the result of their very painstaking and continued sessions were later reported to the convention on Thursday morning, as will hereafter appear.

WEDNESDAY MORNING SESSION

The first order of business on Wednesday morning was the report of the Committee on Time and Place of Convention city for 1913. Mr. Chas. J. Wangler, chairman, submitted the report, which reported in favor of Cleveland, and Mr. Wangler further explained that, in the opinion of the committee, this was the most practicable point to insure a good attendance and had received the endorsement to the committee of both the manufacturers present and the supply men. The report was unanimously accepted and Cleveland selected as the convention city of 1913, when the Silver Anniversary of the association will be celebrated.

Election of Officers

Mr. George N. Riley, chairman of the Nominating Committee, presented the report of that committee, which was unanimously accepted and the nominees therein duly elected as follows:

President—E. D. Meier, New York.
First Vice-President—T. M. Rees, Pittsburg, Pa.
Second Vice-President—J. D. Smith, Charleston, S. C.
Third Vice-President—W. A. Brunner, Phillipsburg, N. J.
Fourth Vice-President—H. D. MacKinnon, Bay City, Mich.
Fifth Vice-President—M. J. Broderick, Muncie, Ind.
Treasurer—Joseph F. Wangler, St. Louis, Mo.
Secretary—J. D. Farasey, East Thirty-seventh street and Erie Railway, Cleveland, Ohio.

The various officers-elect responded in suitable manner, acknowledging the compliment paid them; Colonel Meier, as president-elect, being the first to respond. Col. Meier congratulated the association upon the fact that the attendance at the present convention, at a point so far South, reflected favorably upon the interest and enthusiasm of the membership and proved that the growth of the association was healthy. We believed that it was also an endorsement of the new departure in the way of hearing papers upon technical subjects to a greater extent than had formerly been the case. The papers contributed were appropriate and of an exceedingly interesting and practical character. He thanked the association for their renewal of confidence. Secretary Farasey, in responding to his election, referred to the good work done by Secretary Slocum, of the Supplymen's Association, in his efforts to secure a large attendance here and to increase the membership during the past year. He deprecated the fact that out of a list of possible members of 750 boiler manufacturers in the United States, as his data showed, and a considerably larger number as reported by the supply men, the association has only, perhaps, 25 percent of the possibilities enrolled, and he urged all to make greater efforts for increase of membership during the coming year with a view to making the Cleveland convention the banner meeting.

Secretary Farasey announced the death, in November last, of Mr. Hugh Tudor, of Cincinnati, an esteemed member of the association, and on motion of Mr. Connelly, Messrs. Champion, Connelly and Wangler were appointed a committee to draft suitable resolutions.

The report of the Auditing Committee was read and accepted, pronouncing the secretary-treasurer's accounts correct in all details.

Mr. George Thomas, 3d, of the Parkesburg Iron Co., announced that Mr. H. A. Beale, Jr., who had been requested to give a paper on charcoal iron boiler tubes, was unable to be present; and as Mr. Beale has been connected with that manufacture all his life, Mr. Thomas regretted that the association would not at this time have the benefit of his knowledge and experience. In his absence Mr. Thomas presented a paper entitled "History of Charcoal Iron and the Manufacture of Charcoal Iron Boiler Tubes."[1]

Manufacture of Charcoal Iron Boiler Tubes

Following the paper Mr. Thomas showed a series of interesting slides, being mill views illustrative of good practice, in the course of which he remarked that it takes to-day about three carloads of charcoal to make fifty tons of charcoal iron. The convention showed its interest by close attention and putting questions to the speaker relative to the slides, which were courteously answered by Mr. Thomas. In reply to a question as to what variation in gage would reject a tube on inspection at the mill, Mr. Thomas stated that a variation of one point would do so, but that generally customers did not object to a tube being slightly heavy. These and other similar queries indicated that the boiler manufacturers desired to know whether the manufacture was carefully conducted and under close inspection.

Manufacture of Seamless Steel Boiler Tubes

Mr. J. Jay Dunn, of the Shelby Tube Company, Ellwood City, Pa., favored the convention with a paper on "Manufacture of Seamless Steel Boiler Tubes,"[2] also illustrated by lantern slides.

Segregation in Steel

In introducing Mr. Charles L. Huston, vice-president of the Lukens Iron and Steel Co., who delivered a paper on "Segregation in Steel,"[3] President Meier remarked that the general subject of segregation is one of intense interest to both mechanical engineers and metallurgists as well as manufacturers, and that Mr. Huston's paper was one that had required much time and labor in its careful preparation, and would in every way prove instructive to boiler manufacturers.

Mr. Huston's paper was not only illustrated by lantern slides, but also by numerous diagrams, some of which Mr. Huston had, as he explained, used in a former paper, "Experiments on the Segregation in Steel Ingots in Its Relation to Plate Specifications," read before the American Society for Testing Materials, appearing in Volume VI. of the Proceedings of that organization.

Messrs. S. F. Jeter, of the Hartford Steam Boiler Inspection and Insurance Company; J. W. Kelly, of the National Tube Company, Pittsburg; H. J. Hartley, of the Cramp Ship Building Company, and Col. E. D. Meier, of the Heine Safety Boiler Company, took part in the discussion, during the course of which the speaker quoted in part from his former paper above referred to. He commented on the generally admitted fact of the difficulty of maintaining a close guaranty on the sulphur content, and therefore plate manufacturers want a little margin over the guaranty. He thought that the sulphur did not affect the working of the steel after it gets out of the boiler makers' hands to any serious extent, so far as any tests that had come to his knowledge; but steel manufacturers were generally able to keep the phosphorus down, the latter very seldom getting above .02 in basic. In acid steel it is difficult to get it down below .03. Manufacturers, however, endeavor to meet requirements so far as lies in their power, but the speaker maintained that to require too close a margin in sulphur would result in the throwing out of material which the manufacturers think is as available for service.

Mr. Jeter asked with regard to the analysis from ladle tests, and the speaker replied that it kept the manufacturers busy to get the content down to .03 sulphur in the ladle test, and .03 or .025 is all that can be gotten here. Of course, when you get to the center of the ingot you can get it closer. The manufacturers' endeavor is to aim at the best quality possible. To that end considerable shearing is sometimes necessary on the top and bottom to get down to sound plate.

In reply to Mr. Jeter's question as to whether the tensile strength and the elongation of steel plates would vary materially when taken transversely across the direction of rolling as compared with the usual practice of taking them longitudinally with the direction of rolling, the speaker stated that if the test pieces were carefully prepared, so as not to taper in the dressed-out portions of the test pieces, there will be very little difference either in the tensile strength or the elongation, but the reduction of area depends upon the fracture, and is considerably less in the transverse than in the longitudinal test pieces.

A query from Mr. Hartley brought forth from the speaker that tests for tensile strength show higher results generally on the transverse than the longitudinal tests, but practically the same as to reduction of area.

In reply to a query from Col. Meier as to whether certain figures shown on diagrams were of specimens taken from the sheet, or from the billet, the speaker explained that the diagram showed in every case the location from which they were taken, these in some cases being from the heart of the billet. Where plate analysis is shown it means that both surfaces were scraped off, and then a clean drilled hole run entirely through the plate at the location designated, in that way getting the full average. The test pieces were taken after rolling. Comparisons were shown of results under transverse and longitudinal tests, at different locations in the plate.

Mr. Kelly asked why the sheet was sheared lengthwise for test strips, to which Mr. Huston replied: "Because you get a more satisfactory test piece from the side than you can from the end, owing to the variation in the thickness of the plate between the edge and the center caused by the spring of the rolls in service, making it almost impossible to get a test piece crosswise of the plate that is not tapering in thickness."

Mr. Hartley expressed pleasure to hear that there was so little difference in the results from transverse and longitudinal, to which the speaker replied that, although the tensile strength was nearly equal, the ductility as shown by reduction of area is very much less, while the elongation is nearly the same.

Col. Meier answered that what was necessary to be considered is elongation rather than reduction of area, as the latter does not come in at all in the limits of boiler manufacture works. Mr. Huston agreed to this as far as the specifications are concerned, but said that it still plays a part in the value of the metal, because if you examine a test piece you will find that the elongation in the lingitudinal test piece is obtained very largely from the extreme amount of stretch. If you watch the testing machine you will find that it lets go after the metal has reached its maximum strength, quite a while before it breaks. On the other hand, in the transverse specimens you will find that it will not let go until after it has reached the maximum; it will hold it up right until it breaks: showing that there is an after-stretch after it has sustained its full load, which you do not find in the other. There is a final stretch right where it goes off, which shows an additional element of safety in the longitudinal. With regard to reduction of area, the speaker called attention to some of the figures, showing this to be on longitudinal test 52.7 and 53.3, as compared with transverse and similar elongations of 48.1 and 45.0 percent. Mr. Huston asked if it was not true that the type of boiler with a single bottom seam from single sheets had not been practically abandoned? Mr. Hartley replied that that was true of light material, but he now referred to

[1] An abstract of this paper will be published in the May number.
[2] An abstract of this paper will be published in the May number.
[3] An abstract of this paper is printed on page 116.

material up to 1½ inches thick. Scotch boilers of 12 to 13 feet were all made that way. Mr. Huston thought that it was really better for safety that one-inch plate be rolled down to 15/16 inch, and he had in his paper presented before the Franklin Institute made a recommendation of that kind. He had been informed that the German practice restricts the tensile strength to 56,000 pounds. In this country, taking the standard limits of 55,000 to 65,000 pounds on most specifications, 55,000 pounds would be the strength that the safety factor of steam stresses would be figured upon, and he believed that is a safe limit, although he stated that his concern is making higher steels all the time when they are specified by the Government. They had also made some very high tensile strength steel not long ago for some of the Canadian provinces, yet the speaker did not think it was wise to use such in the manufacture of boilers. Such high tensile strength steel will not curl off, but will crack or break off, which would not indicate that it is good for boiler use, yet it is being ordered and furnished on such orders all the time, and so specified in Government specifications.

Col. Meier responded that the A. B. M. A. had entered their protest to the United States Government against that, in response to which the Government had reduced it to 65,000 pounds tensile strength, and he did not believe that any steel was safe for boiler purposes at 75,000 pounds tensile strength. Mr. Huston said that the steel that they made at 60,000 to 62,000, heavy plate, when it is rolled down to 15/16 inch is safer than 1¼-inch plate that has not been so rolled down.

Mr. Connelly asked whether it was not desirable to run the tensile strength higher in steel castings, to which the speaker made answer that that was out of his line. Continuing, Mr. Huston said that, in order to avoid a seam over the fire in horizontal tubular boilers, it had formerly been supposed to be a great thing for them to make a heavy boiler in one sheet and show no seam exposed to the fire. He was not familiar with the reasons why that had been abandoned, but he understood that that idea had been given up entirely. Col. Meier replied that when you test a boiler like that it will assume a barrel shape, the metal giving away first. Tests made in Chicago in 1893 proved that conclusively. Mr. Kelly suggested that the continuation of the girth seam was necessary to produce uniform conditions all around the boiler, to which Mr. Meier agreed.

Mr. Kelly asked the speaker what was the cause of the spots which in flanging boiler plate develop at the flanging point, and whether anything can be done to remedy the same; to which the speaker replied that he regretted he had not with him any suitable diagrams to illustrate the matter more fully, but if you were to cut ⅛-inch off of the service in the mill you would find holes about ⅛ inch in diameter running from an inch to an inch and a quarter into the depth of the metal, just like honeycomb. These are squeezed up more or less in the rolling, but if they are next to the edge of the plate they will open up. They may be right at the surface. To reduce these to the minimum, it is necessary to closely watch the temperature and other conditions of the metal, so as to get them driven in from the surface as far as possible, which is the best that can be done. They do less harm the further they are in. In shearing an especially thick plate which has not received sufficient rolling, this condition is more pronounced. Mr. Kelly asked if shearing would remove this, and the speaker replied to the contrary, because they run clear across the surface of the plate to some extent, more so in the heavier plate.

Mr. Kelly suggested that probably sufficient shearing was not done before the plates were sent to the consumer, and Mr. Huston replied that if more shearing were done it would enhance the cost to the boiler manufacturer. With a view to remedying this condition experiments had been made with titanium, vanadium and ferro-silicon. The latter runs it into the pipe. Manganese has been tried, but is liable to produce large blisters in the plate. Prof. Howe has gone very thoroughly into this matter, and at his request a series of experiments was undertaken by the speakers concerned. The specific gravity was determined of the ingot with the holes in it. It was then sliced nearly into the center line of the ingot, reheated and rolled, and a piece cut from the corresponding portion of the outside edge of the ingot. This was polished and its structure was examined under the microscope, showing that this process had practically distributed the holes. The mill is now carefully watching the temperature of the pouring, and fluoride of calcium is thrown in at the critical moment as judged by the conditions of the temperature and slag, and the degree of fluidity of the pour.

Mr. Kelly asked whether there was any objection to rolling the sheet lengthwise, or with the sheet, so far as tensile strength is concerned; to which the speaker replied that he supposed Mr. Kelly meant, by rolling, the bending of the rolls. Generally speaking, under most conditions, the speaker did not believe that it would give as good results as bending it the other way.

An adjournment was now taken until 2:30 P. M.

WEDNESDAY AFTERNOON SESSION

At the opening of the Wednesday afternoon session Mr. S. F. Jeter, supervising inspector Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn., read a paper on "Boiler Explosions, Their Causes and Prevention."*

Boiler Explosions; Cause and Prevention

Mr. Jeter explained that Mr. Allen, of his company, had been asked to present a paper on this subject but was unable to do so, which Mr. Jeter regretted, inasmuch as out of Mr. Allen's larger experience he might have brought in a paper that would have been of greater interest. The speaker stated that he could not fully cover so extensive and important a field in a necessarily brief paper, but would take up the question in a limited way.

In the discussion following, Col. Meier remarked that the State, municipal and insurance inspectors, so far as their inspection in boiler shops and during the process of the construction of boilers, have always been very strict, and in most cases very wise; but if both municipal, State and insurance inspectors would do still more to protect the boiler manufacturer by more frequent and thorough inspection of the boilers after they leave the manufacturer's hands and are in service, it would be well, inasmuch as the majority of the troubles referred to by Mr. Jeter may be traced to the improper care of boilers, something over which the manufacturer has absolutely no control. All future legislation ought to emphasize that feature. This has been brought to the attention of the Board of Boiler Rules in Massachusetts as a very important matter, no less in importance than the rules made for the construction of boilers. Mistakes are sometimes made in the repair of boilers, President Meier remarked, and in illustration he called upon Mr. John T. Corbett to present to the convention an illustration of this, a remarkable piece of repair work.

Mr. Corbett made some very Mark Twainesque comments, of a sarcastic and humorous character, as to a peculiar repair which he explained by a pencil sketch. The case was reported in one of the technical magazines. Mr. Corbett compared the method of repair here used to an operation for appendicitis, and thought that the man who did it should have his photograph placed, not in the Rogues' Gallery, but in some equally conspicuous place. The sketch showed a bulge occurring in a horizontal tubular boiler, in the bottom shell be-

* This paper is printed on page 119.

hind the bridge wall. This was braced by putting a one-inch rod through the boiler, carrying it up between the tubes, and just above the tubes making an offset of 12 inches, and carrying the rod on through the top of the shell. The description by Mr. Corbett and his comment on this wonderful piece of repair work elicited hearty laughter and applause, and the recommendation that the originator of the device be awarded a gold medal was concurred in. Col. Meier said this was a case where the boiler was probably all right when it was first built, but the method of repair should have been under some regulation.

Modern Boiler Shops

Mr. H. C. Meinholtz, of the Heine Safety Boiler Company, St. Louis, Mo., presented a paper on "Modern Boiler Shops, and How Same Should be Equipped."[1] He explained that it was quite impossible to write a paper that would be applicable to all conditions, and he had accordingly endeavored to present one extremely short and covering only the main points.

In connection with his paper Mr. Meinholtz exhibited lantern slide views of the new plant of the Heine Safety Boiler Company recently erected at St. Louis. While showing these slides he incidentally mentioned the method adopted of stopping a leak in their accumulator by filling with Portland cement under hydrostatic pressure. This reference later brought forth an inquiry from Mr. Hartley as to what method had been adopted in the Heine plant for preventing freezing in the accumulator cylinder. Mr. Meinholtz explained that their hydraulic system was drained every day in extremely cold weather. The shop is heated, and kept at a fairly warm temperature during the day, and the shop temperature does not fall sufficiently during the night to freeze the accumulator by morning even when the temperature outside is ten degrees below zero. Mr. Hartley remarked that in the case of a similar leak in his shop they had used glycerine, which was very good and not expensive. They had previously been using a compound manufactured by the Solvay Process Co., which ate through the cylinder, apparently causing the leak. The leak, however, was not stopped, and it was found necessary to purchase a new cylinder. Mr. Meinholtz stated that his company did not use any lubricant at all in the accumulator—nothing but pure water.

Compressed Air in Boiler Shops

Mr. Thomas Aldcorn, of the Chicago Pneumatic Tool Co., New York City, delivered his paper on "The Use of Compressed Air in Boiler Shops,"[2] which paper, he stated, dwelt more especially with installation rather than use, although the title would indicate otherwise. Aside from his paper, Mr. Aldcorn remarked that he had omitted to mention that in shop equipment it was advisable to include gasoline or kerosene driven compressors for field work, a knock-down plant that could be readily taken out in the field where it might not be possible to obtain electricity, or where it would be extremely expensive to install a steam plant. Small gas or kerosene driven units can be obtained which are very economical in use, and can be run with about a pint of gasoline per horsepower per hour, or ⅝ of a pint of kerosene. Very compact machines, direct driven, the same as direct-line steam compressors, are very largely in use at this time, and are found very satisfactory in working outside plants.

The A. B. M. A. as It is and as It Should Be

Mr. W. H. S. Bateman, of the Supplymen's Association, before presenting his paper, made a few remarks, stating that he had been commissioned by Mr. Richard Hammond, of Buffalo, one of the past presidents of the A. B. M. A., and who was one of the original charter members of the association as well as a member of the first committee appointed on uniform boiler specifications, to convey his very best wishes to the president, officers and members, and to say that now is the psychological moment to urge upon State and provincial legislative bodies in this country and Canada the passage of uniform laws for construction, care and maintenance of boilers. Mr. Bateman also referred to his own connection with the association and his having been always a constant and earnest advocate of all measures looking to the up-building of the A. B. M. A., not from a selfish or mercenary standpoint or with any axe to grind, but from broader motives. He believed that he was as well acquainted with boiler manufacturers, both here and in Canada, as any other man in his line, and he spoke from his heart in saying that the A. B. M. A. ought to represent a much larger percentage of manufacturers than at present. Increased numbers and strength in the organization would redound both to the benefit of the boiler manufacturers and the manufacturers of materials, whose interests are mutual.

Mr. Bateman also paid a high compliment to the work of Mr. Slocum, of Brooklyn, whose unselfish and energetic efforts had so largely contributed to the attendance and success of the present convention. Mr. Slocum worked to extend the membership, his labors to that end being untiring and unceasing, and Mr. Bateman thought that Mr. Slocum had reason to be proud of the results. He prophesied still further evidence of Mr. Slocum's good work at the convention next year in Cleveland, the Silver Anniversary of the association.

Mr. Bateman congratulated the convention on the increasingly amicable relations between the boiler manufacturers and the manufacturers of materials, and pointed to the array of blueprints and diagrams displayed in view of the audience, and which had been used to illustrate Mr. Huston's paper, as an ocular evidence of the pains the manufacturers were taking to co-operate with the association on best lines.

After paying a high compliment to Mr. Huston's ability and research, Mr. Bateman read a letter from a certain manufacturing concern which had no representative present at this convention, which letter contained certain criticisms which those present plainly saw were founded upon misapprehension of the work of the association and failure to understand what the association had been doing and the heavy odds against which it had been working in its endeavors to benefit both members and non-members. This letter brought forth a protest from several of the members present, who were surprised that criticism should be offered by one who could not possibly, by reason of his absence from the deliberations of the association, have realized what work it was doing, when it was within his power to become a positive instead of a negative quantity in constructive work for the benefit of the entire trade as well as the consuming public. The fact that Mr. Bateman referred to the gentleman who wrote the letter in high terms as an authority in the trade, did not relieve that gentleman in the eyes of the members present from the responsibility which he should cheerfully assume of joining the association, taking part in its work and in the carrying forward of its plans, that have only one object, the betterment of the entire community by the manufacture of the best possible product. One point brought out by the letter, however, was the impression in the mind of the writer that the association had needlessly endorsed certain legislation, which Col. Meier now explained was incorrect; but on the other hand, while the association has constantly endeavored to avoid needless antagonisms, it has taken advantage of any and every opportunity to forward the great principle for which it stands, the protection of the public and manufacturers alike, by discouraging inferior workmanship and materials, and seeking to secure and maintain the highest standards both on the part of boiler manufacturers and of those who cater to their needs.

The absence from the meeting of prominent Chicago boiler

[1] An abstract of this paper will be published in the May number.
[2] An abstract of this paper will be published in the May number.

manufacturers, non-members, was commented on, and the efforts that had been made by Mr. George A. Reese, vice-president and manager of the Chicago Pneumatic Tool Company, to bring a big delegation from Chicago were recited. It appeared that Mr. Reese had previous to the convention invited twenty of the Chicago manufacturers to a dinner, and received twelve acceptances, only four of whom sat at table with him, illustrating the difficulty of persuading the Chicago manufacturers to get together. Mr. Slocum announced that out of twenty-six Chicago boiler manufacturers only one was present, Mr. Hibben, the mention of whose name now brought out a round of applause.

In commenting upon Mr. Bateman's paper, President Meier doubted whether it would be possible to introduce as many different sections or classifications of the work of the association as a practical measure of policy and do equal justice to all. Efforts had been made from the beginning to have State committees, but for some reason the effort had not up to the present time met with much success. President Meier recalled the time when prominent Chicago manufacturers, such as Moore and Bee and others, had taken a great interest in the work of the association, and he regretted that others had not risen to take their places as representatives from a city where the association at one time had a large membership. The association in general cannot be justly blamed for the defection of the Chicago manufacturers, because they locally cannot get together, and it is hoped this condition may improve. Each city has its own problems to work out and must take care of itself. In this day and generation almost all business men are recognizing the advantages of co-operation, and it is certainly unfair that members of any trade, profession or calling should sit idly by, waiting for others to do that which is to inure to the common benefit of all in the trade.

So far as complaint made by non-members of the organization that this association has endorsed certain State legislation, notably that of Massachusetts, such endorsement has never gone further than in a general way to commend the good that was in the law and the regulations under it, and where it was imperfect to use the best efforts at command to have it amended. If those who take no part in the work of requesting these improvements will come to the meetings and do their share of the work, they will not only be better informed as to what is being attempted and what is being done for the benefit of all the trade, as well as our own members, but they will feel that they are fulfilling their obligations to their time, to their communities and to their brothers in the business. Mr. John A. Stevens, one of the members of the Massachusetts Board of Boiler Rules, has acknowledged frankly that the rules adopted, while appearing to the judgment of the board as the best possible for them at the time to prepare, were, of course, subject to reasonable amendment, were not claimed to be perfect in all details, and were not put forth as the sum of human wisdom. Col. Meier expressed his gratitude in this connection to those gentlemen of the association, his colleagues on the Committee on Uniform Boiler Specifications, who during the present meeting have taken the time from social pleasures to meet in the committee room and go carefully over numerous proposed amendments, with a view to having those that met approval adopted by the Massachusetts Board of Boiler Rules. This association will always be ready to co-operate in any good work looking toward the betterment of trade conditions and better service to the public.

Mr. Bateman remarked that, on behalf of the gentleman whose letter he had read, he wished to say that the gentleman had attended the last convention of the A. B. M. A.

Capt. J. A. Cotter, U. S. Inspector Steamboat Inspection Service, 10th District, the special representative of General Geo. Uhler, Inspector-General, at this convention, was given the privilege of the floor and acknowledged the bouquets handed out by Mr. Bateman in his paper to the Steamboat Inspection Service, of which Mr. Cotter had been a member for the last fourteen years. He did not wish to take to the board itself all the credit for the excellent amendments and revision of the rules which have been made from time to time during that period, but the same were largely due to the conferences and consultations held by the board with the boiler manufacturers of the United States, members of this association; and from the information derived from them the board had formulated its rules. He was glad to have Mr. Bateman say that they are a good set of rules. For some years other departments of Government had in a measure held aloof from the Steamboat Inspection service, and the work of the Board was confined wholly to the inspection of marine boilers, but now the Government in its Quartermaster's Department, Light-House Board, and other departments has extended the duties of the Board of Inspection of Steam Vessels so that the boilers in all these other departments are now under the supervision of the board and the importance of their work is being more generally recognized.

Colonel Meier called the attention of the association to a pamphlet, copies of which were distributed, entitled "Railway Business Association Bulletin No. 10," "Duty of the Railways to the Shippers; shall they be equipped to fulfill it?" issued February 23, 1912. This association has a representative membership of strong business concerns, shippers and manufacturers, a list of these being given in the pamphlet, which sets forth the reciprocal duties of railroads and shippers, the enormous increase of transportation and the need for increased facilities to handle it successfully and efficiently; that the current increase in facilities is inadequate, as is generally conceded; the vast investments that necessarily must be made to amend these conditions and furnish more nearly adequate equipment, etc.; that roadroad managers hesitate to make improvements, no matter how much needed, unless assured of the certainty of financial support to the extent needed; that the public must be made clearly to understand the necessity for a return to investors in railroad securities sufficient to attract capital to such investments, etc.

Col. Meier explained that there was a call for co-operation between the shippers and the railroads, looking to the betterment of trade conditions; that although there once was a time when railroads adopted an arbitrary attitude towards the public and an unfortunate remark of a moneyed man is often quoted who, under temporary irritation because of unwarranted interference with what he considered his own business, had used the expression, "The public be d——d," this was not representative of the position taken by enlightened and broadminded railroad presidents and other officials of railroads, and this was proven in one case very conspicuously by the recent circulation broadcast of instructions to the New York Central employees to treat the public at all times with the courtesy and consideration due them; and to use all means to change the feeling, that has been too common, that railroad corporations are soulless. He urged upon the membership a careful reading of the pamphlet. If the railroads prosper, all of our communities will partake of that prosperity, and of course it is unnecessary to state that all those trades which are engaged in furnishing supplies to them will certainly feel the stimulation that will come. If the railroads are not sufficiently equipped to properly handle the business of the country and freight congestion ensues, the country will suffer irreparable loss. Great difficulty is being experienced by railroads in marketing their securities abroad because of the fear there of adverse and continual legislation detrimental to the railroads. This is a condition that should be and must be remedied or it will work ill to other lines of business here. All the railroad interests want is common fairness and just consideration.

At the request of Mr. Bateman, of the Supplymen's Association, Mr. Slocum, the efficient secretary of the supplymen's organization, was given the floor, and briefly told the work done during the past year in the direction of increasing membership in the A. B. M. A., and plans for the future. He stated that one reason why manufacturers did not come to the convention was because they would stay at home and read the proceedings. It was necessary to stop this stay-at-home-and-read-the-procedings business. He explained that, perhaps, it was not generally known that the entertainment furnished was through the efforts of the Supplymen's Association, and those material men who contribute to this end should receive the encouragement of the boiler manufacturers when looking about to purchase materials. He had personally carried on a publicity campaign and had been in correspondence during the year with some twenty-seven of the leading trade journals in the United States and Canada, all of whom had most kindly co-operated with the work of the Committee on Extension of Membership and had generally published articles sent them from time to time. During January and February some 6,000 letters had been sent out, and some of the results would probably not be apparent until the meeting at Cleveland next year.

THURSDAY MORNING SESSION

Thursday morning's session opened with a paper by Mr. H. J. Hartley, entitled "Generalities Pertaining to the Boiler Manufacturing Business."

Secretary Farasey read the report of the Committee on Memorial to Mr. Hugh Tudor, as follows:

Report of Special Committee

"As we gather for our Annual Convention here this year, we are called upon to record the death of our esteemed friend and associate, Mr. Hugh Tudor, who was called to his eternal reward November 19, 1911.

"Mr. Tudor was one of our charter members, and during his active business years he attended our meetings regularly and aided us by his wise counsel. In his death his family have lost a good father; we have lost a loyal friend, a worthy associate and a staunch supporter.

"We regret that due notice of his death did not reach our secretary promptly, and we now hasten to extend to his bereaved family our sincere sympathy and therefore:

Resolved, That a copy of these resolutions be inscribed on our minutes and presented to his family with our sincere sympathy.

"David J. Champion,
"L. E. Connelly,
"Chas. J. Wangler,
"American Boiler Manufacturers' Association."

The report was adopted unanimously by rising vote.

The Sothern Boiler Works, Belleville, Ill., and A. T. Scannell, Chicago, Ill., were elected to active membership. A letter was read from H. A. Baumhart, manager of the Cleveland department of the Hartford Steam Boiler Inspection and Insurance Company, regretting his absence and forwarding copy of recently revised Book of Rules formulated by the Ohio Board of Boiler Rules. Mr. Baumhart stated that the question of uniform boiler inspection laws throughout the United States is an important one, and he trusted that the A. B. M. A. would take some decided action with regard to it; as an inspector of steam boilers he fully realized its necessity. Mr. Baumhart expressed his willingness and desire to cooperate with this association and proffered membership. He was accepted and elected as an associate member.

A letter was read from Mr. W. O. Hart, of Dinkelspiel, Hart & Davey, attorneys at law, New Orleans, La., stating that, as one of the Commissioners on Uniform State Laws from the State of Louisiana and a member of the National Conference of Commissioners in which every State and Territory is now represented, he had read with interest the newspaper publication that the A. B. M. A. had under discussion uniform laws in reference to boiler inspection, and that he would be glad to be informed of the details, so that he might present the matter before the conference of his organization which is to meet at Milwaukee about August 20th next, and to which he would be glad to have the A. B. M. A. send a representative. He closed by expressing his willingness to explain the work of the Conference on Uniform State Laws, and thereby if possible advance the object of this association.

Mr. Hart was asked to address the convention, which he did in an interesting manner, explaining at some length the work accomplished by his organization in forwarding uniform laws relative to warehouse receipts, bills of lading, vital statistics, divorce, etc., etc. He repeated his offer to aid in any way he could to secure uniform laws relative to boiler inspection. A vote of thanks was tendered to Mr. Hart and his offer was accepted to have a representative at the Milwaukee meeting. Later, on Mr. Honhorst's motion, Mr. L. E. Connelly was selected as such representative.

Topical Questions

The following topical questions were reported by Mr. J. Don Smith, chairman of Committee on Topical Questions, and on motion same were passed for consideration through the mail and also at the Cleveland convention, viz.:

1. Bagging of the bottom of a horizontal tubular boiler.
   (*a*) Have you had success in pushing the "bag" back to its proper place.
   (*b*) Is it physically and commercially the best method?
   (*c*) What is the best method of treatment?
   (*d*) Have you applied a patch by any welding process?

2. After a boiler shell or seam has ruptured (having been in use at least fifteen years), will a sample of the material undergo, or show as good a "test" as when it was new?

3. How much variation from a true circle is commercially allowable with, say, a 72-inch diameter boiler when "set" ready for use?

4. Has the oxyacetylene welding process been sufficiently developed to warrant its use in boiler making?

5. What is the relative value of Spelerized American ingot iron and charcoal iron boiler tubes?

6. Electrolysis in boilers; has any one had any experience with same?

7. When boilers are not in use, which is the better method, to leave full of water or empty same?

J. Don Smith,
Chas. J. Wangler,
James C. Stewart, Committee.

Resolutions of thanks for courtesies were, on motion of Secretary Farasey, adopted by unanimous vote, as follows:

"The American Boiler Manufacturers' Association, in Twenty-fourth Annual Convention assembled, fully appreciating the royal welcome given us in the grand old city of New Orleans, the Queen of Southern ports, hereby tender our grateful acknowledgment to the following: To the Honorable Martin Behrman, Mayor of the City, for his heartfelt and earnest address of welcome; to Mr. J. W. Porch, president of the Progressive Union, who so interestingly added to the Mayor's remarks at our opening session; to Mr. W. H. S. Bateman, the Old Reliable, who responded in his witty and pleasing fashion to the welcoming addresses, and to Mr. J. H. Murphy, local representative of the manufacturers.

"We also wish to tender our thanks to Mr. J. H. Cotter, representing General Uhler, of the U. S. Steamboat Inspection Service, who has charmed us all by his genial presence; to Messrs. D. J. Champion, Thomas Aldcorn, S. F. Jeter, W. H. S. Bateman, Chas. L. Huston, George Thomas, 3d, H. J. Hartley, H. C. Meinholtz and J. Jay Dunn for interesting and instructive papers read; to Messrs. John T. Corbett, F. B. Slocum, H. B. Hare, as also all of the associate members, for their ideal management and enjoyable entertainment; to Messrs. J. H. Murphy, J. W. Porch and Hugh Weidman, who so successfully looked after our wants. To the press, both daily and technical, for their full and fair reports of our various sessions; to the hotel attendants, who in every capacity looked after our comfort, and to all who have in any manner made our stay most enjoyable and long to be remembered. And last, but by no means least, to the ladies of New Orleans, who have so willingly and unremittingly extended to our own ladies visiting New Orleans those kind attentions which only ladies as hostesses understand so well how to perform."

The passage of these resolutions was reported to the ladies at the banquet and ratified by them.

Col. E. D. Meier, chairman of Committee on Uniform Boiler Specifications, read the report of that committee, as follows:

Report of Committee on Uniform Boiler Specifications to the American Boiler Manufacturers' Association

Your committee on uniform boiler specifications, having duly considered the present situation in regard to uniform laws for the construction and care of boilers and the history of the movement, beg leave to report as follows:

This movement was inaugurated in 1889, at the first convention of this association, held in Pittsburg, Pa. The first practical action taken was to formulate certain specifications in regard to materials. At that time the general trend toward the substitution of steel for iron in boiler construction was in its beginning. After the first committee on specifications had formulated rules for steel, a demand was made and a motion passed instructing the committee to report also specifications for iron. This was accordingly done, but there is no record of these specifications ever having come into practical use.

The specifications for steel were formulated after hearings given by the committee to engineers and metallurgists representing the steel manufacturers, and the first report was discussed in every detail on the floor of the convention to which the reperesentatives of the steel interests contributed, having been accorded the privilege of the floor for that purpose. The consequence was a fair compromise on mooted questions which gave satisfaction to both our membership and the steel makers.

In subsequent years a number of committees on uniform boiler laws were appointed, and all of them did yeoman's service in the various States in which boiler laws were proposed. Not a single one was successful; for after the most strenuous efforts with able arguments in which members of various societies of practical engineers co-operated, the measures were in each case defeated by adverse interests, mainly those dominated by manufacturers engaged in the mass production of small boilers for agricultural and oil-boring industries.

In the meantime, during eight following conventions, topical discussions on mehods of manufacture were held in which the leading practical boiler manufacturers of the country took active part.

In 1896 the two committees on materials and on uniform boiler laws were merged into the committee on uniform American boiler specifications. After a preliminary report in 1897 to the ninth annual convention, this committee was instructed to prepare a complete set of boiler specifications based on the results of the experience embodied in the topical discussions referred to.

In the summer of 1898 the committee met at Atlantic City and elaborated a set of rules covering, in a practical and general manner, all the important details of materials and workmanship.

These were reported to the tenth annual convention at St. Louis, in October, 1898, and after a discussion occupying three full days, in which every article was carefully discussed and many modifications adopted, the convention on October 6, 1898, unanimously adopted the specifications thus amended. They will be found in full, with the discussions preceding their adoption, in the Proceedings of 1898. The chairman was then instructed to edit all this material, with a view to cutting out any superfluous matter and arguments and stating the conclusions in short mandatory sentences. This was done in thirty-one short paragraphs, divided into five sections, viz.:

(1) Materials.
(2) Workmanship and dimensions.
(3) Factor of safety.
(4) Hydrostatic pressure.
(5) Hanging or supporting the boiler.

In this form these uniform American boiler specifications were widely distributed in the United States, as well as in foreign countries, and in consequence they were frequently embodied in specifications from engineers asking for bids on work. In the conventions of 1905, 1909 and 1910, they were further discussed and modified, such changes as were found necessary being in every case adopted by unanimous vote.

The attempt to have these specifications adopted into the laws of various States was formally abandoned by a general agreement among those most active in the work that an educational campaign would have a wider and more permanent effect, and that a general acquiescence of parties interested either as producers or consumers must precede all legislation.

Our association can justly claim that its work on these lines had a determining influence in the movement toward State and municipal laws which has been in progress during the last ten years; in fact, many of the practical conclusions of our work have been embodied in the boiler inspection law of the State of Massachusetts. This was conceded in the discussions at the Detroit convention in 1909, in which a general endorsement of the Massachusetts boiler rules was unanimously adopted.

This endorsement has been misunderstood and misrepresented as pledging the American Boiler Manufacturers' Association to every detail of these rules; whereas the truth is that this association always has and always will maintain its right and duty to work for further improvement and amendment in every case where the practical working of any law or rules indicates the necessity therefor.

At the Boston convention in 1911, the request was made to our members in Massachusetts to formulate from their experience suggestions for such modifications. Your chairman further invited all members of the committee to a careful study of these rules, to which several members have responded. These various reports were laid before your committee here on the 12th inst., and fully discussed on that and the following day, and a unanimous agreement reached on the points in question. While your committee reasserts its full concurrence in the uniform American boiler specifications as issued by our association, and will continue to hold them as the foundation for its further work, it seems most convenient to at this time carefully consider modifications and improvements suggested by the experience of our membership, in the existing Massachusetts boiler rules as being those which have longest stood the test of practical use.

Part I. of these rules does not apply to boilers constructed after May 1, 1908. In Part II., section 1, your committee recommends changing the pressure allowed on a boiler constructed wholly of cast iron from 25 pounds to 15 pounds, such boilers to be used only for heating purposes. Your committee sees no reason for advising any change from the conclusions covering cast iron as stated in our original specifications of 1889. We consider that heating boilers built entirely of steel should be allowed a pressure not exceeding 25 pounds per square inch. We consider the allowance of 95,000 pounds per square inch as resistance to crushing of mild steel to be just, and agree also to the allowance for shearing strength of rivets given in paragraph 5.

We disagree with paragraph 7, fixing the factors of safety on old boilers according to age, holding that that should be based on the actual physical condition of the boiler at the time of inspection.

As to section 2, paragraph 8, we disagree with the general prohibition of cast iron seats for safety valves; the universal satisfactory experience on the navigable waters of the Mississippi Valley with lever safety valves having cast iron seats precludes this discrimination.

We disagree with the provision of paragraph 9 prescribing a bearing surface of the disk of safety valves at an angle of 45 degrees, on the ground that the experience of reputable manufacturers of standard pop safety valves shows the flat seat to be equally safe and effective, which fact is corroborated by the careful investigation of Prof. Edward F. Miller, of the Massachusetts Institute of Technology, on this subject.

As to paragraph 11, we hold that the maximum diameter of the fusible metal in safety plugs should not exceed ⅜ inch.

Section 6, paragraphs 1, 2 and 3, we believe should be replaced by paragraph 30 of the A. B. M. A. specifications, viz.: The hydraulic test, to be made on completed boilers built strictly to these specifications, is never to exceed working pressure by more than one-third of itself, and this excess limited to 100 pounds per square inch. The water used for testing to have a temperature of at least 125 degrees F.

Part III., section 1, in place of paragraphs 1, 2, 3, 4, 5, 6, 7 and 8, covering the chemical and physical properties of the tests of boiler and rivet steel, we recommend the substitution of paragraphs 1, 2 and 3 of the uniform American boiler specifications covering the same ground.

Paragraph 16, same section, we recommend omitting the table of allowances for over-weight on plates, and the substitution therefor of the following rule:

Plates will be considered up to gage if measuring not over .01 inch less than the specified gage.

We hold that paragraphs 1, 2 and 3 of section 2, Part III., should be annulled, and that the qualities ascertained by actual test of plates should be conclusive as defining material to be used, instead of such indefinite designations as "flange," "firebox," or "extra soft" steel.

Part III., section 2, paragraph 7, should be amended by prohibiting the use of cast iron for mud drums.

Section 3, paragraph 2, we hold that this paragraph, providing that the stamp (Mass. standard) shall be affixed by the inspector, etc., shall not be construed to compel the manufacturer to stop or retard work in process or prior to completion on account of the temporary absence of the inspector.

We hold that paragraph 6 of section 4, which limits boilers of lap-riveted construction to 100 pounds per square inch, and to a diameter not exceeding 36 inches, is not warranted by the experience of reputable boiler manufacturers. Lap-riveted boilers of 48 inches in diameter have been and are in successful use on the Mississippi River and its tributaries at pressures up to 200 pounds. While of course a State law would not govern the construction of boilers for steamers on the navigable waters of the country, the practice in most of the cities and towns located on these waters naturally follows the satisfactory practice of the Steamboat Inspection Service.

We hold that paragraph 10 of section 4 should be modified so that a manufacturer, so long as he uses plates of sufficient gage under these rules, may use with them other plates of a somewhat thicker gage which he happens to have in stock.

As to paragraph 16, we find that there has been a misunderstanding in regard to which is a convex and which is a concave head. We suggest that these heads be designated as "externally convex" and "externally concave." We further suggest that the constant in the formula for the externally concave head be increased from .6 to .8, as found necessary from the experience of the Steamboat Inspection Service.

We recommend that, in order to avoid misunderstandings, paragraphs 17 and 18 should be combined in one paragraph, so that it is clearly understood that the convex, or concave, head which has a manhole opening shall have an increased thickness of ⅛ inch and a turned in flange of a depth of not less than three times the thickness of the head.

In paragraph 19, we hold that the word "flat" should be omitted so that the minimum thickness of plate in all stayed surfaces shall be 5/16 inch.

In paragraph 21, we would suggest that this be amended so that an increased pitch of not over 1½ inches be allowed in the stay-bolts adjacent to the furnace door or hand-hole opening, but in one direction only.

In paragraph 23, we would recommend that for small steel heating boilers limited to 25 pounds and under no stay-bolts be required.

In paragraph 25, we would recommend that, to avoid misunderstanding, the language be amended to the effect that the "pitch of stay-bolts shall be measured on the inside of the furnace."

In paragraph 32, we recommend that the stays specified on each side of the manhole in horizontal return tubular boilers shall not be required to pass through the front head, because of the difficulty in keeping these joints tight; and that other equally strong means of staying may be adopted.

Paragraphs 40 and 41; we recommend that these paragraphs be placed in harmony with the present Manufacturers' Standard. A recent agreement reached between expert committees of the Society of Mechanical Engineers and the Master Steam Fitters' Association has defined thicknesses and flanges for such fittings.

In paragraph 43, we recommend that this be amended so as to correspond to a recent ruling by the Board of Boiler Rules that this does not apply to the holes in the fittings.

We recommend that paragraph 45 be eliminated, because it is not possible to comply with it in the case of rivets driven by air tools or by hand, which always must be employed where hydraulic riveters cannot reach; and a rule should not discriminate against smaller boiler shops unable to supply themselves with hydraulic riveters.

In paragraph 48, we recommend that this rule be amended by omitting everything after the word "chamfered," so that it shall read: "48. The edges of tube holes shall be chamfered."

We recommend that in paragraph 49 the word "carefully" be substituted for the word "substantially," so that the rule will read: "49. A fire-tube boiler shall have the ends of the tubes carefully beaded."

We hold that paragraph 53 should be amended to allow the use of pressed steel and wrought iron nozzles in addition to those specified.

In paragraph 54, we recommend the use of the word "oval" instead of the word "elliptical," in designating the shape of the manhole opening.

Paragraph 59 should be amended to permit the use of cast iron manhole plates, which are universally used in the boilers in the Middle West.

Paragraphs 60 and 61 should be amended so as to make it optional whether a manhole or a hand-hole shall be used in the front head of horizontal tubular boilers.

We recommend that paragraph 62 be eliminated, because it is a very difficult and precarious thing to keep a hand-hole in good order in the rear head of a horizontal tubular boiler below the tubes.

Paragraph 63, we hold that the requirement of a hand-hole near the throat sheet of a horizontal tubular boiler should be eliminated by striking out the words "also where possible one near the throat sheet."

In paragraph 65, substitute ¾ inch for 1 inch pipe size.

Paragraphs 67, 68 and 69, which definitely prescribe the hanging or support of large tubular boilers, should be eliminated and manufacturers permitted to follow their present practice, which has been proved to be safe.

Paragraph 70, we recommend be struck out, and in lieu thereof paragraph 31 of the Uniform American Boiler Specifications substituted.

Section 5, paragraph 3, change 2 inches to 3 inches.

Paragraph 5 has given rise to misunderstandings and should be re-written, to make it clear that two valves are required to be placed on any individual steam pipe leading from a boiler to a steam main or to another boiler, in the interest of the safety of any man entering such boiler while the other boiler or boilers are in service.

We recommend in paragraph 18 the substitution of the words "100 pounds" for "135 pounds."

In paragraph 23 add the words "except such portion of the piping as is exposed to the gases of combustion."

We recommend that the paragraph 31 should be placed under section 1, Part II., referring to cast iron boilers.

We recommend that in paragraph 3 of section 6 the sentences (*a*) and (*b*) be cut out, as they discriminate against lap-riveted joints, which are in satisfactory use in thousands of boilers in the Middle West.

We further recommend that in the same paragraph the sentences (*d*) and (*e*) be eliminated, and that the factor of safety be based on actual conditions of the boilers instead of their age; and we further recommend that the last sentence covering hydrostatic pressure test should be eliminated, and paragraph 30 of the Uniform American Boiler Specifications substituted.

While recognizing the great care with which these rules have been prepared, we are struck by the fact that there are a number of requirements stated in pages far apart each from the others which, for convenience of manufacturers and inspectors and to prevent misunderstandings, should be grouped together.

Your committee would remark, in conclusion, that, inasmuch as these rules have been and will undoubtedly further be used as models for rules in other States than Massachusetts, we sincerely trust that our recommendations herein set forth in regard to these matters will be fairly and favorably considered by the Massachusetts Board of Boiler Rules, and we shall submit these recommendations, in the event that they meet the approval of this convention, to said Board as experts in the confident belief that their desire will coincide with ours to further perfect these rules issued by them.

Respectfully submitted, E. D. Meier, chairman; Thomas M. Rees, Barth Scannell, Henry J. Hartley, Charles F. Koopman, Jr., A. J. Schaaf, H. C. Meinholtz, William A. Brunner, committee on uniform specifications.

The report was given close attention and greeted with applause. Mr. Brunner moved its acceptance and the adoption of the recommendations therein, and that the committee be continued. The motion carried unanimously. Mr. Brunner called attention to the importance of a clear understanding as to the meaning of the terms "convex" and "concave" as applied to heads, as it appeared that two interpretations had been placed upon them, one holding that they were intended to be used with reference to the direction of pressure upon the head, and the other view being that the terms applied only to the external contour as viewed from without. President Meier explained that the recommendation in the report had been made with a view to removing any indefiniteness that might attach to the use of the terms and the interpretation placed on same.

Mr. L. E. Connelly, of the D. Connelly Boiler Company, Cleveland, made a strong plea for the passage of uniform laws for boiler inspection in all States of the Union and Territories, as well as the Canadian provinces. He gave a practical illustration of hardship in loss of time and money in a case where a boat was built for work in one harbor and upon being towed to another at great expense was at first ruled out of commission there because of different requirements as to the boilers than in the State where the boat had been built and the boilers installed and accepted.

Mr. Connelly urged that more radical steps be taken than in the past to secure the passage of uniform State legislation with regard to boiler inspection in all States that have not yet adopted such laws, and on his motion a resolution was adopted instructing the secretary to print copies of the report of the committee, and circulate same to all members and invite their comment and criticism, with a view to further conference by the committee; the committee to act in the meanwhile upon any proposed additional amendments or improvements, with the ultimate design of perfecting a model bill that might be pushed for general adoption by all States.

Upon the motion of Mr. Koopman, the name of Mr. Brunner was added to the present Committee on Uniform Boiler Specifications serving at this convention, and Mr. Brunner affixed his signature in approval of their report.

On further motion by Mr. Koopman, of Massachusetts, a unanimous vote of thanks was tendered to Mr. James Stewart, of Worcester, Mass., for his careful study and recommendations of changes in the Massachusetts rules, many of which were incorporated in the report of the committee.

Mr. Hartley stated that he had at one time, when preparing a paper that he presented to the convention at a former session, written to the Governors of all States in the Union, requesting to be advised as to whether the States written to had any statutes relative to boiler inspection, safety, and insurance of boilers; he received quite generally replies to his letters from the Governors addressed; and so far as he was then able to learn, only five States in the Union had such statutes. He thought that this was something needing amendment.

In reply to an inquiry put to him, Mr. Hart stated that Federal legislation was not possible relative to stationary or land boilers, and the only way to reach them was through State legislation, which he thought should be uniform.

At the suggestion of Secretary Farasey, Mr. L. E. Connelly was deputized to confer with the Ohio State Board of Boiler Rules and recommend to their favorable consideration the adoption of amendments reported on favorably by the committee as to the Massachusetts Board Rules, with a view to at least securing uniformity in these two important manufacturing States.

Mr. Koopman voiced the thanks of the Massachusetts members for the very cordial way in which other members had co-operated with them in their desire to have amendments made in the Massachusetts Board of Boiler Rules, regulations, and in adopting at this session amendments and improvemetns proposed by them.

On motion, resolutions were adopted as forwarded by the Railway Business Association along general lines of deprecating the hysterical legislation of recent years aimed at railroads simply because they are railroads, and forgetting that, as they are a component part of the business of the country, attacks made upon them simply as corporations and without reason are not only reprehensible morally speaking as being unjust, but hurt all our securities abroad, and prevent the very thing that business men are demanding of the railroads, that they shall increase their equipment so as to take care of business sufficiently.

Entertainment

At the banquet Thursday night, at the St. Charles, some 125 ladies and gentlemen sat at table, Col. E. D. Meier officiating as toastmaster in his usual pleasing fashion. An especially appreciated feature was the presentation, on behalf of the Supplymen's Association, by Mr. Thos. Aldcorn, of a silver set of five pieces to Mr. John Corbett, re-elected president of the associate members' organization. Toasts were responded to by Messrs. J. W. Porch, president Progressive Union, John Murphy, of the Local Committee; Secretary Farasey Capt, Cotter, representing Gen. Uhler; Mr. Sayles, of Cleveland, and Mr. W. P. Luck.

The associate members held meetings coincidentally with the sessions of the parent body and re-elected their former officers, with one exception, the officers elected being as follows: J. T. Corbett, president; Thomas Aldcorn, vice-president; H. B. Hare, treasurer; F. B. Slocum, secretary. Executive Committee—W. O. Duntley, chairman, Chicago; W. H. S. Bateman, Philadelphia; D. J. Champion, Cleveland; T. P. Wallace, St. Louis, Mo.; J. W. Porch, New Orleans, La.

Elaborate arrangements for the ladies' entertainment were made and carried out efficiently and in a manner satisfactory to all; automobile ride, reception and lunch for visiting ladies on Tuesday; matinee at Dauphine Theater Wednesday for ladies, and a theater party at the Crescent for all, Wednesday night, after which dinner at the Grunewald Cave. On Thursday a boat ride and luncheon on the *Sidney*, viewing the harbor and the Mississippi river.

Registration of attendance at A. B. M. A. convention:

Thomas Aldcorn, Chicago Pneumatic Tool Company, New York, N. Y.
Mrs. J. B. Ayers, Cleveland, Ohio.
A. S. Amer, New Orleans, La.
Mrs. A. S. Amer.
Mr. and Mrs. J. S. Barelli, Heine Safety Boiler Company, New Orleans, La.
Miss Holbrook, with J. S. Barelli.
D. A. Brown, official reporter, Cincinnati, Ohio.
W. H. S. Bateman, Philadelphia, Pa., representing Champion Rivet Company and Parkesburg Iron Company.
Mrs. W. H. S. Bateman, Mrs. A. S. Ennes, Master Huston Bateman and Stanley Bateman.
W. A. Brunner, Mrs. W. A. Brunner, Tippet & Woods, Phillipsburg, N. J.
R. T. Burwell, chief inspector Hartford Steam Boiler Inspection and Insurance Company.
John C. Brill, Mrs. John C. Brill, Portsmouth Steel Company.
D. J. Champion, Mrs. D. J. Champion, Champion Rivet Company, Cleveland, Ohio.
John Corbett, president Supply Men's Association, Jos. T. Ryerson & Son, Chicago, Ill.
Mr. and Mrs. L. E. Connelly, D. Connelly Boiler Company, Cleveland, Ohio.
Miss Sue Crawford, Philadelphia, Pa.
John A. Cotter, supervising inspector steam vessels, Tenth District, New Orleans, La.
Miss Alice Cotter, New Orleans, La.
J. F. Duntley, Mrs. J. F. Duntley, Chicago Pneumatic Tool Company, Detroit, Mich.
Mrs. H. F. Deverell, Otis Steel Company, New Orleans, La.
Alex Dussel, Mrs. Alex Dussel, Alex Dussel & Co., New Orleans, La.
J. D. Farasey, Teachout Boiler Works, Cleveland, Ohio.
Mrs. J. D. Farasey, Miss Marie Farasey.
J. J. Finnigan, J. J. Finnigan & Co., Atlanta, Ga.
S. A. Fortsen, Lombard Iron Works, Augusta, Ga.
H. B. Hare, Cleveland, Ohio, treasurer Supply Men's Association, assistant secretary Otis Steel Company.
Mrs. H. B. Hare.
George Hayes, Mrs. George Hayes, Chicago Pneumatic Tool Company, Chicago, Ill.
H. J. Hartley, Cramp Ship Building Company, Philadelphia, Pa.
James Kelly, James Kelly Iron Works, New Orleans, La.
Mrs. James Kelly, Florence Kelly, Agnes Kelly.
William P. Luck, New Orleans, La., representing Erie City Iron Works, Erie, Pa.
Mrs. Wm. P. Luck.
F. W. Milbourn, sales manager Southern Engine & Boiler Works, Jackson, Tenn.
Mrs. F. W. Milbourn.
Col. E. D. Meier, New York, N. Y., president Heine Safety Boiler Company.
W. C. Honhorst, McIlvain & Siegel, Cincinnati, Ohio.
S. H. Daniels, Walsh & Weidner Blr. Company, Chattanooga, Tenn.
John Mulrooney, Mrs. John Mulrooney, guest D. J. Champion, Cleveland, Ohio.
J. H. Nicholson, first vice-president National Tube Company, Pittsburg, Pa.
James W. Porch, New Orleans, La., representing Lukens Iron & Steel Company.
Mrs. James W. Porch, Miss Rita Porch.
Wm. A. Porteous, manager Western Union Telegraph Company.
T. F. Rowland, Jr., president Continental Iron Works, New York.
Mrs. T. F. Rowland.
George N. Riley, Mrs. G. N. Riley, National Tube Company, Pittsburg, Pa.
George Reese, Chicago, Ill., vice-president Chicago Pneumatic Tool Company.
Mrs. Geo. Reese.
Arthur L. Rice, managing editor *Practical Engineer*, Chicago, Ill.
S. F. Jeter, supervising inspector Hartford Steam Boiler Insurance and Inspection Company, Hartford, Conn.
Fred L. Joubert, Mrs. Fred L. Joubert, Payne & Joubert, New Orleans, La.
J. J. Kelley, National Tube Company, Pittsburg, Pa.
Mrs. Kittredge, guest J. J. Finnigan & Co.
C. F. Koopman, Boston, Mass.
C. B. King, chief engineer Marion Steam Shovel Company, Marion, O.
Fred R. Low, editor *Power*, New York, N. Y.
Mrs. Fred R. Low.
George Mason, Scully Steel & Iron Company, Chicago, Ill.
John A. Murphy, Miss Edna Murphy, Miss Sue Murphy, New Orleans, La.
A. B. Murray, guest E. McCabe, New York, N. Y.
E. F. McCabe, McCabe Boiler Works, Newark, N. J.
Robert Munroe, Jr., Pittsburg, Pa.
D. M. Montgomery, Monongahela Tube Company, New Orleans, La.
Mrs. D. M. Montgomery.
G. A. MacLean, representing A. M. Lockett & Co., New Orleans, La.
Mrs. G. A. MacLean.
Emil W. Ritter, Mrs. Emil W. Ritter, Burke Furnace Company, Chicago, Ill.
E. J. Ross, Mrs. E. J. Ross, Bancroft, Ross & Sinclair, New Orleans, La.
Capt. T. M. Rees, James Rees & Sons, Pittsburg, Pa.
F. B. Slocum, Continental Iron Works, Brooklyn, N. Y.
J. Don Smith, Valk & Murdock Iron Works, Charleston, S. C.
W. D. Sayle, president Cleveland Punch & Shear Works, Cleveland, O.
Mrs. W. D. Sayle, Miss Winifred Swift.
T. J. Smalwood, Birmingham, Chicago Pneumatic Tool Company.
B. Scannell, Lowell, Mass., Scannell Boiler Works.
Miss Katharine Scannell, Miss Mary Scannell.
Arthur Scannell, Chicago, Ill., president Archer Iron Works.
A. J. Schaaf, chief engineer Monongahela River Coal & Coke Company, Pittsburg, Pa.
F. C. Severin, Cleveland Pneumatic Tool Co., Birmingham.
David L. Schofield, National Tube Company, New Orleans, La.
J. H. Smythe, Parkesburg Iron Company, Parkesburg, Pa.
P. J. Stakelum, Payne & Joubert, New Orleans, La.
George Thomas, 3d, Mrs. George Thomas, 3d, treasurer Parkesburg Iron Company, Parkesburg, Pa.
Mr. Thompson, Scully Steel & Iron Company, Minneapolis, Minn.
Charles Tudor, Mrs. Chas. Tudor, Tudor Boiler Manufacturing Company, Cincinnati, Ohio.
John Thrash, Dallas Boiler Works, Dallas, Tex.
Eugene Unsworth, Hartford Steam Boiler Insurance and Inspection Company, New Orleans, La.
Capt. Thos. Woodward, New Orleans, La.
Tarver Waddell, Mrs. Tarver Waddell, A. M. Lockett & Co., New Orleans, La.
M. G. Weidner, Walsh & Weidner Boiler Company, Chattanooga, Tenn.
T. P. Wallace, Hagar Iron Company, St. Louis, Mo.
C. L. Wilson, Memphis, Tenn., district locomotive boiler inspector, with Interstate Commerce Commission.
Hugo Weidmann, Mrs. Hugo Weidmann, National Tube Co., New Orleans, La.
C. C. West, Manitowoc Boiler Works, Manitowoc, Wis.
Chas. J. Wangler, Wangler Boiler & Sheet Iron Works, St. Louis, Mo.
Edgar Whitehead, National Tube Company, New Orleans, La.
Daniel C. Dugan, New Orleans, La.
W. K. DePass, Standard Supply Company, New Orleans, La.
J. Jay Dunn, Elwood City, Pa., general superintendent Shelby Steel Tube Company.
John S. Fouche, Cincinnati Iron & Steel Co., Cincinnati, Ohio.
W. B. Harris, Worth Bros. Company, Cincinnati, Ohio.
C. L. Huston, vice-president Lukens Iron & Steel Company, Coatesville, Pa.
J. Isselhardt, Southern Boiler Works, Belleville, Ill.
Daniel Jeffrey, Jeanerette, La.
James R. Mills, Carnegie Steel Company, New Orleans, La.
I. B. Maitland, E. Keeler Company, Williamsport, Pa.
Jack Moses, Jos. T. Ryerson & Son, Chicago, Ill.
Austin M. Mueller, assistant sales manager, Jos. T. Ryerson & Son, Chicago, Ill.
H. C. Meinholtz, Heine Safety Boiler Company, St. Louis, Mo.
A. W. Whiteford, mechanical manager Jacobs-Shupert Fire Box Company, New York.
W. S. Taylor, Portsmouth, Ohio.
George Hibben, Hibben & Company, Chicago, Ill.
H. O. Pfeiffer.
F. J. Durdan, Pittsburg, Pa.
M. H. Brunt, Mon. River Con. Coal & Coke Company, Pittsburg, Pa.

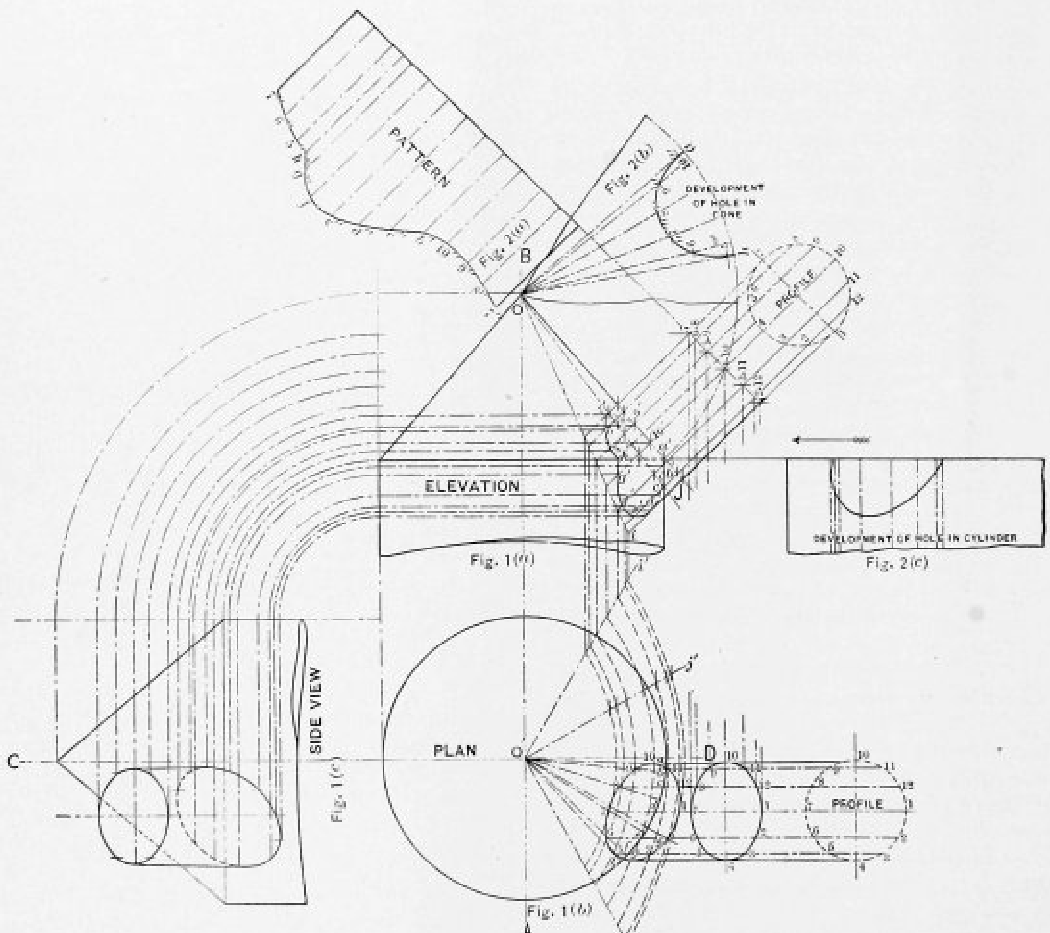
The Baldwin Locomotive Works has taken orders for forty large Mikado-type locomotives for the Chicago, Rock Island & Pacific Railroad, as well as nine of the Pacific type for the Southern Railway. A very fair number of orders for single engines for industrial concerns have also been received. While its plant is still being operated on a very restricted basis, one of the officials of the company states that the outlook is more favorable.—*Iron Age.*

Lay-Out of a Cylinder Intersecting a Cone and Cylinder Obliquely

BY C. B. LINSTROM

Connections of this kind are usually encountered in woodworking plants where shaving and dust collecting systems are employed in carrying off waste matter and dust from machines to either the boiler room or yard. The solution of this problem is not in the least complicated and no new principles of development are involved, but since the arrangement of the connection is unusual it may be of interest.

Referring to Fig. 1 (*a*), the elevation shows clearly how the inlet pipe is to connect to the cone and cylinder. Fig. 1 (*b*) represents the plan of this connection, and it will be noted the inlet pipe in the required position. In this case it is shown to the left of the center line *C D*. Upon the axis of the small pipe in both views draw the required profiles. Divide the circumferences of same into any number of equal parts; in this case 12, as indicated by the numerals. Now proceed to find the miter line or line of connection between the three objects as required in order to lay off the patterns for the inlet pipe and holes in the cone and large cylinder. The simplest way of doing this is to find first the line of connection between the cone and cylinder. The edges of the cone, there-



that the inlet pipe is off center and to the left of the center line *C-D*. Fig. 1 (*c*) is a side view, as would be seen in viewing the object in the direction indicated by the arrow shown to the right of the elevation. The small cylinder in this construction intersects both cylinder and cone. By a careful inspection of the drawings it will be readily understood how to proceed for finding the line of intersection between the three connections.

The first operation necessary in order to make the development is to draw the horizontal and vertical center lines *A B* and *C D*. Upon *A B* draw the elevation of cone, cylinder and inlet pipe in their relative positions and according to required dimensions. Where *A B* and *C D* intersect determines the center for drawing the circle plan view. In the plan arrange fore, are prolonged an indefinite length. Planes are then passed through the inlet pipe and through the cone parallel to the axis of the small cylinder. To understand what this means, conceive in the imagination that a plane, as a sheet of paper, is passed through points 6-8 of the profile parallel to the inlet pipe's axis. On the drawing the plane cannot be seen, but we do see a straight line running parallel with the axis of the pipe. This line is called a trace of the plane. All of the construction lines drawn on the elevation of the pipe represent traces of planes. From the above it will be understood that a trace of a plane is a line which represents the intersection of an auxiliary plane with either the horizontal, side or front principal planes. In all construction drawing of this kind the use of auxiliary planes is of great advantage in finding correct developments. Auxiliary planes are either parallel or oblique to the principal planes. Where any two surfaces meet they have a common line of intersection. This may be a straight line or a curved line, depending upon the shape of intersecting surfaces. Therefore the inclined planes which are drawn through the cylinder parallel to its axis and through the cone will produce sections of the cone which will be either elliptic, parabolic or hyperbolic in shape, depending upon the inclination of the cutting plane. For example, where a plane is parallel with the base of a right cone and cuts all elements of the cone, the intersection line of the plane with the surface of the cone is a circle. As soon as the plane is inclined the section becomes elliptical. The plane must pass through the cone to produce a circle and an ellipse.

When a cutting plane makes the same angle as the slope of the cone, the section produced is a parabola. In this case the curve does not close, as in the case of the ellipse and circle, as the cutting plane passes through only a part of the cone. The parabola can be obtained by passing a plane through at one angle only, which must be equal to the slope of the cone.

The hyperbola is produced by passing a plane through the cone parallel to its axis, but not through it. When the angle of the cutting plane becomes greater than the angle of the slope of the cone, the section produced is a hyperbola and remains so from this position up to and including a vertical position of the cutting plane. A cutting plane passed directly through the axis of the cone will produce a triangle.

The irregular dotted curved lines in the plan are sections of the cone as they appear looking directly down upon the sections. Before these curves can be formed, it is first necessary to pass planes through the cone directly through its axis. Where the auxiliary planes drawn through the cylinder intersect the planes of the cone determines the irregular sections in the plan. The traces of the planes of the cone will be radial lines on the elevation, and in the plan as *O-i* and *O-j* of the elevation and *O'-i'*, *O'-j'* of the plan.

An inspection of Figs. 1 (*a*) and (*b*) show very clearly how the curves of the sections are found. Before the line of connection between the three objects can be found, perpendicular plans must be passed through the cone and inlet cylinder intersecting the sections produced by the planes already shown and explained. The traces of the vertical planes are shown in the plan passing through the inlet cylinder and intersecting the irregular curves at points 1, 2, 3, 4 to 12 inclusive, which gives the required points through which the curve of the hole in the plan is to be drawn. It will be understood from the plan that the hole shown from points 10, 11, 12, 1, 2, 3, 4 and 5 is the view of the hole in the cone which was extended. The shape of the required hole in this problem lies within the points 10, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, 5, 6, etc.

The miter line is now readily determined by erecting perpendiculars from these points in the plan to the corresponding construction lines as shown at *a'*, *b'*, *c'*, *d'*, 10', 9' and 8', etc. Draw in the curve for the miter, thus completing the elevation.

Development of Patterns

Fig. 2 (*a*) is the required pattern of the branch pipe. Draw a stretchout line equal to the distance of the circumference of the pipe. If the plate is made of light gage iron no allowances need be made for the take-up or rolling. However, if heavy plate is used, determine the required stretchout by multiplying the neutral diameter of the pipe by the constant 3.1416. Divide the stretchout line into 12 equal parts in this case. Through these points and at right angles to the stretchout line draw the dotted construction lines. Transfer from the drawing Fig. 1 (*a*) the required lengths of lines for developing the pattern.

The development of the hole in the pattern of the cylinder is shown constructed at Fig. 2 (*c*). Set off the distances *a-b*, *b-c*, *c-d*, etc., of the plan on the horizontal line. Project from the elevation the corresponding points until they intersect the required construction lines. Through their points of intersection draw the curve of the hole.

Fig. 2 (*b*) shows the construction of the hole in the pattern of the cone. The drawing shows clearly how it was determined.

The Scotch Marine Boiler

There appear from time to time discussions on boiler construction, mainly referring to the riveting, bracing and style of joint to be used, thereby giving the impression that these are the main features to be looked into when purchasing boilers.

Many engineers and owners think the return-tubular boiler is the only type that should be installed. I think this opinion is mainly due to lack of knowledge of other types.

I have had a number of years' experience with the return-tubular boiler and have concluded it is the least really improved type of boiler in general use, everything considered.

Safety is the most important of all points to be considered, and this is the weakest point in the return-tubular boiler. Why is it more liable to explosion and other troubles than other types? Because the most important part of the boiler (the outside), being of large diameter, is subject to excessive heat, caused by the collection of impurities between steel and water and extreme changes of temperature. Then consider the minor faults. The blow-off pipe must be covered or it is very dangerous, and when covered is not always easy to examine. The water column usually is too far from the boiler and has too many bends. I have seen the lower pipe as long as 75 inches.

It takes too long to cool a return-tubular boiler, as it has so much brickwork around it.

While I have never given the different types a test for circulation, I have decided that the return-tubular boiler has the poorest circulation of the boilers in general use. This is due to the even distribution of the applied heat.

While I am not an agent of any boiler-making firm, I am a strong advocate of the Scotch marine internally-fired boiler for stationary use. If engineers and owners would study boilers more, and the steam-engine indicator and the condenser less, I think it would be time well spent.

The Scotch marine boiler is built upon scientific principles and designed to suit requirements. It is not subjected to violent explosions, as the inside parts are the weaker and show signs of distress first. If anything should give way the result would not be of a disastrous nature. Some authorities claim that this type has a poor circulation. It cannot have a poorer circulation than the return-tubular boiler, as the heat is so evenly distributed to the water.

A representative of a return-tubular boiler manufacturing company advised me never to recommend a Scotch marine boiler to prospective buyers, his excuse being, "They are fierce when they get dirty." Is not any boiler fierce when it gets dirty?

For economy the Scotch marine heads the list when properly handled, especially in long runs. The water and steel are all that have to be heated. The loss of heat is only up the stack, if the boiler is insulated properly. The cost of up-keep should be low, as this type of boiler is simple, convenient and has few parts to give trouble. It does not require over four to six hours to cool sufficiently for it to be comfortable to work inside, and it does not occupy nearly as much space per unit of capacity as other types. They have no large, hot combustion chamber to be cleaned on hot summer days.

I consider an investment in a good internally-fired Scotch marine boiler a good dividend payer.—Ray Gilbert in *Power*.

Hydraulic Riveting*

BY H. J. HARTLEY

The following remarks contained in this article are upon the subject of hydraulic pressures as applied to riveting, and were inspired by the leading topical subject designated as No. 1 (*a*) in the list of Topical Subjects presented by Mr. J. Don Smith, chairman of the committee on "Topical Questions," at the meeting of the association held in Boston, Mass., in 1911.

In reading over the comments upon that important subject, as published in the proceedings, I was impressed with the idea that the question had not been fully discussed, nor appreciated as being the most vital unit in the whole structure of a boiler. If there are other parts included in the structure of a boiler that have been done roughly and in a crude manner, and if the riveting has been properly done, the faulty work otherwise is thereby redeemed, and the credit of the whole has been preserved. While, on the other hand, the workmanship otherwise may be of the highest class throughout the boiler, but if the riveting has been badly done, the vitality of the whole structure is vitiated, and after being put in service, as a natural consequence, leakage becomes a source of trouble and the boiler has short life. Unfortunately this fault is not always manifest at the time of the first inspection, but develops weakness later on when put in service, very much to the disgust of all concerned, and especially to the inspector who has conscientiously passed the job.

Considerable diversity of opinion seems to exist upon the pressure per square inch of rivet section required for all classes of boiler work.

At the present time the importance of having rivets to completely fill the holes is more fully realized and insisted upon being so in all classes of work than was the case twenty years ago.

Under the old system of hand riveting as formerly practiced, with the holes much too large for the size of rivets to be driven therein, doubtless much imperfect work was made, which was, and still is, a fruitful source of disaster, as rivets with loose fitting bodies or shanks are not only imperfect in themselves, but they allow undue weakness in the plates, owing to unequal and incomplete bearing surfaces. Hence the strongest joint has been found by experiment to be that in which the area of the rivet body exceeds the net sectional area of the plate; the increased friction on the bearing surfaces, and grip of the rivet heads on the plates more than compensating for the reduced plate area.

When riveted joints are being formed, the tendency is for the rivet to be upset on the ends where the final head is being formed, the friction in the rivet hole resisting its flow to some extent.

The tendency will also be for the rivet to fill the hole completely at the one (blank) end less perfectly at the end next to the original head.

It is, therefore, conducive to tight work to have a fillet under the head of the rivet which will, welge-like, jam into the slightly countersunk hole, thus insuring, at least without the necessity of calking, a water-tight rivet, provided the plates composing the joint have been properly fitted, and the rivet holes made fair and of proper size for the rivets to be used. The allowance on increased sizes of rivet holes for heat expansion, over the sizes of the rivets to be driven, in first-class high-pressure boiler work, should not exceed the following fractional numerals, namely:

Advancing by 1/8-inch.

For a 3/4-inch	diameter	plus	1/32-inch
For a 7/8-inch	"	"	3/64-inch
For a 1 -inch	"	"	3/64-inch
For a 1 1/8-inch	"	"	3/64-inch
For a 1 1/4-inch	"	"	1/16-inch
For a 1 3/8-inch	"	"	1/16-inch
For a 1 1/2-inch	"	"	1/16-inch

and so on proportionately.

All rivets should be heated to a medium cherry red at the head, and, if possible, to a dark cherry red at the points.

In regard to the pressures required for driving rivets cold for tank and stack work, as frequently required, I would recall some experiments made by Wm. Sellers & Company between the compression platforms of their Emery testing machine.

A number of 3/8-inch size rivets were subject to pressures between 10,000 and 60,000 pounds with the following results:

At 10,000 pounds the rivet swelled and filled the hole.

At 20,000 pounds the head was well formed;

At 30,000 pounds the rivet was well upset and headed; and

At 40,000 pounds the metal plates surrounding the rivets began to stretch and became more apparent as the pressure was increased to 60,000 pounds.

From these experiments the conclusion might be drawn that the pressure required for driving and heading *cold* rivets is about 150 tons—300,000 pounds per square inch of rivet section.

About the same time the test referred to, as made by Wm. Sellers & Co., a series of tests for determining the test pressures for driving rivets in high-pressure steam boilers was also made at the Baldwin Locomotive Works, by Mr. Vauclain, with the following results:

Six sets of 9/16-inch plates were selected and prepared for the tests, each set being composed of six plates, these being drilled for rivets varying in size by one-eighth, from 5/8-inch to 1 1/4 inches in diameter.

In the first set the 5/8 inch rivets were driven with a pressure of 25 tons; the second set the 3/4 inch rivets were driven with a pressure of 33 tons; in the third set the 7/8 inch rivets were driven with a pressure of 50 tons; in the fourth set the 1 inch rivets were driven with a pressure of 66 tons; in the fifth set the 1 1/8-inch rivets were driven with a pressure of 75 tons; and in the sixth set the 1 1/4-inch rivets were driven with a pressure of 100 tons.

The specimens were then cut in half, longitudinally, through the rivet, which showed that where a pressure of 33 tons had been applied the metal under and around the heads of the 5/8-inch rivets was indented or compressed. When 50 tons on both the 5/8-inch and 3/4-inch had been applied, the same effect was shown, and so on up to 100 tons pressure; all of which showed more or less indentations, excepting the 1 1/4-inch rivets.

In a second test similarly conducted the rivet holes were punched instead of drilled, the only difference in the result being that the plates showed no indentation and the holes were all filled. The conclusion was that the suitable static pressure for 5/8-inch rivets is 25 tons; for 3/4-inch rivets, 33 tons; for 7/8-inch rivets, 50 tons; for 1-inch rivets, 66 tons;

* A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

for 1⅛-inch rivets, 75 tons, and for 1¼-inch rivets, 100 tons.

The conclusions drawn from the foregoing tests, when converted into pressure per square inch of rivet section, would be, in even pounds, approximately as follows:

Diameter of Rivets	Pressure per Square Inch in Pounds.
⅝ inch	163,000
¾ inch	149,000
⅞ inch	166,200
1 inch	168,000
1⅛ inches	151,200
1¼ inches	163,000
Average	160,000

Example—Static pressure, 25 tons = 50,000 pounds, divided by area of ⅝-inch rivet = .3680 = 162,952 pounds pressure per square inch of rivet section.

The average of the above pressures per square inch of rivet section is 160,000 pounds, which may be used in calculating the necessary pressures for rivets of other sizes. Therefore, it will be noticed that these figures are in a very convenient shape for practical use.

An experiment was also made in cold riveting, thus: A pair of plates were punched for ¾-inch rivets, which were driven into the holes with the same range of pressure, but it was found that the lower pressures were not sufficient to form the head, whereas the higher ones indented the plates.

The writer has been working under the foregoing described conditions with the same riveting plant for about twenty years, doing all classes of steam-boiler work, varying in thickness of plate from ⅜ inch to 1¾ inches, and in rivets from ⅝ inch to 1½ inches in diameter, with perfect success.

There exists a condition, however, connected with hydraulic riveting, that is especially favorable to rivet compression and the making of tight work, which is generally not known or realized, and is due to an increased pressure at the terminal stroke of the ram over the initial stroke, amounting by experiment to be conditionally as high as 60 percent.

In other words, a static pressure of 1,200 pounds per square inch in an accumulator has shown on the gage at the end of the stroke a momentary impact of 2,000 pounds per square inch. It will be understood that this increased terminal pressure is due to the surge of the accumulator on its sudden arrest at the end of the stroke and at the time when the rivet has become cooled from contact with the water-cooled dies and plates.

Too much value cannot be given to this terminal pressure as a climax to perfection in hydraulic riveting, the effect being about the same as a second pressure on the rivet after partially cooling would be. This advantage is ever there and costs nothing to obtain.

Unlike the extra labor required on hand and pneumatic riveting to accomplish the same object—*tightness*—by having to partly drive a rivet and shift, in order to allow it to cool, to the next; partly drive it and then shift back to the first, finish it, then go again to the last left unfinished, and so on throughout.

In order, however, to obtain the full value of the terminal pressure, it is necessary for the operator to exercise some skill in admitting the initial pressure to the ram. This is done by opening the valve slowly and sufficiently until the hot rivet has been well upset into the hole, after which the full pressure should be applied, which will have the effect of accelerating the descending momentum of the accumulator, thereby causing a suddenly increased pressure on the rivet at the moment of its impact and the rebound, due to cushioning on account of more or less air in the water. This is more apparent with accumulators having small areas of pistons.

The accompanying illustrations will show the shapes of the rivet-heads generally in use by most boiler manufacturers.

Fig. 1 shows the shape of rivet-head mostly used by manufacturers.

Fig. 1 also shows a rivet with pan-shaped head, ready to be driven with cone-shaped dies; the rivet being hot and the initial pressure bearing on the head and point, it necessarily follows that the rivet must flow into the dies before it gets bearing sufficient to squeeze it into the hole; the initial pressure being utilized in filling the dies.

Fig. 2 represents the shape of the rivet-heads after being driven.

Fig. 3 represents a rivet with round-shaped head, with fillet under head, heated and ready to be driven. It will be noticed that the dies on head and point bear more centrally; and while the die at the blank end of the rivet has a slight point bearing like Fig. 1, yet it is so little, due to the head end

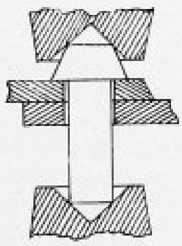


FIG. 1

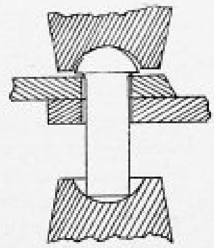


FIG. 3

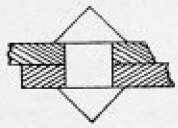


FIG. 2

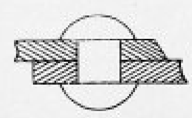


FIG. 4

being solidly and firmly held in the die, that it may be said the initial pressure is bearing centrally on both ends of the rivet, thus permitting the rivet to flow into the hole while filling the radial-shaped dies. In other words, the main feature is accomplished by the rivet filling the hole before the head is formed.

Fig. 4 represents a rivet driven with round-shaped dies in comparison with Fig. 2—cone-shaped dies.

Figs. 2 and 4 show the relative values of the two shaped heads, each having the same quantity of material. The round head will be seen to be the better and also stronger in the shearing section of the head. It is also much easier to calk a round-head than a cone-head rivet, if such should ever be required. The first indentation of the calking tool on a round-head rivet forms an arch or backing to the tool, which has the effect of forcing the metal down to the plate, similar to calking the edge of a seam, while the same operation on a pan and cone-shaped head has a tendency to curl up the thin edges of the rivet on account of insufficient metal above the calking surface.

Master Boiler Makers' Convention

As formerly announced the sixth annual convention of the Master Boiler Makers' Association will be held at the Fort Pitt Hotel, Pittsburg, Pa., May 14, 15, 16 and 17. At the opening session formal addresses will be made by the Mayor of Pittsburg; Mr. D. F. Crawford, general superintendent of motive power, Pennsylvania Railroad; Mr. L. H. Turner, superintendent of motive power, Pittsburg & Lake Erie Railroad, and by Mr. William McConway. These addresses will be responded to by Mr. M. O'Connor, second vice-president of the association; Mr. W. H. Laughridge, chairman of the executive board; Mr. E. W. Rogers, member of the executive board, and Mr. George Wagstaff, past president of the association. The topics to be discussed at the convention are as announced at the last convention.

Segregation in Steel*

BY CHAS. L. HUSTON

Many men, even among those who have long been accustomed to the use of boiler plate steel, have a general impression that a good piece of steel is absolutely uniform in quality and character throughout its whole extent; but those who have examined more deeply into the characteristics of steel soon become aware that in all of our commercial steels we are dealing not with one single metal, even in one picee of steel, large or small, but instead of that we are dealing with a mass in which one metal—iron—predominates, and which is interlarded with other substances or combinations of these other substances with the iron itself, the main distinctive characteristic of steel, as ordinarily found in the market, being that it is a combination of iron with carbon, other elements being present but in very much smaller quantities. These other elements consist mainly of manganese, phosphorus, sulphur, and sometimes silicon and other substances in more or less diminutive quantities.

Now as the carbon and these other substances affect the hardness and ductility of the metal and its working qualities, both hot and cold, it is an interesting study to find out just how these results are distributed throughout the metal.

Of these substances manganese, being the most closely allied to iron in character, seems to be the one which is most intimately combined with the iron and hence varies less in proportion throughout the different parts of a large piece of steel, either in boiler plate or other character of product, while the carbon, phosphorus and sulphur, the other elements usually most observed and reckoned with, are less congenial with the iron than is the managanese, and hence are more likely to be driven out of it in process of cooling, or driven into certain locations in a larger proportion or richer mixture, and thus producing a variation in character throughout different parts of the whole mass.

Steel makers have been studying this problem for a long time, and various schemes, patented and otherwise, have been proposed for meeting it; but, up to this time, so far as your speaker knows, there has been nothing that has secured any recognition in established practice that has gotten rid of the trouble or reduced it other than care in conditions which occur in general steel-making practice, such as temperature of pouring, freedom from burning or oxidation of the metal and other elements of care in melting, refining, pouring, reheating and manipulating it.

A few years ago I had some experiments made and the results tabulated for presentation to the American Society for Testing Materials at a meeting held in Atlantic City in 1906. The tests were made from a number of ingots of varying sizes and proportions, and some varying in chemical character and from boiler plates of ordinary thickness rolled either from these same ingots or from others of corresponding character.

In order to show the distribution or segregation of these various substances throughout the different portions of the mass of metal and the effect produced upon the metal itself by reason of this segregation, an effort being made at the same time to ascertain somewhat the laws under which this segregation took place, a number of these ingots were planed down to sufficient extent to expose the center formation of the steel and photographs taken from the ingots thus cut open; also chemical analyses were made of different portions of some of the ingots, also test pieces taken from the plates to show the corresponding variation in tensile strength and chemical character of the steel.

I have prepared a series of charts, most of which were presented on a previous occasion, but have added some to the further chemical results obtained—first giving only tensile strength and carbon; these charts now showing, in some cases, in addition thereto, the phosphorus, sulphur and managanese.

By examination of these charts, and especially of the photographs attached thereto, it will be noted that there is a peculiar zone of high results in carbon, sulphur and phosphorus, corresponding very closely to a zone of gas holes, which appears always in steel of the character with which I am familiar, viz., soft boiler plate steel, these zones of little gas holes being usually from 1½ inches to 3 inches in from the surface of the ingot; although if care is not exercised in working conditions, temperature, etc., these holes may extend almost out to the very surface of the ingot and bring about a very undesirable condition for securing good clean surface in rolling.

Experiments made by Dr. Henry M. Howe, of Columbia University, New York, since I presented my previous paper at Atlantic City, have indicated that these holes are entirely or mostly closed up in the process of rolling, so that the surfaces, being forced together while the temperature is high, a union takes place of greater or less strength between the two surfaces of the cavities and we have an approximately sound, solid piece of steel plate resulting; but, so far as I know, makers of steel have been unable to entirely eliminate from the ingot these little cavities, which occur in the process of cooling and giving off of gases while cooling, except by the introduction of solidifying elements, such as ferro-silicon, which are used to some extent by steel casting concerns, but which have been found to produce undesirable working qualities in steel for plates and more than neutralize the solidifying value obtained from them.

From these explanations it will be evident that I am confining my remarks entirely to the character of steel usually made for boiler plate, and not dealing with steel used for other purposes, which doubtless has different characteristics, varying with the character of the requirements in amount of carbon and other elements, which are all more or less governed by the kind of service for which the steel is made and worked into shape.

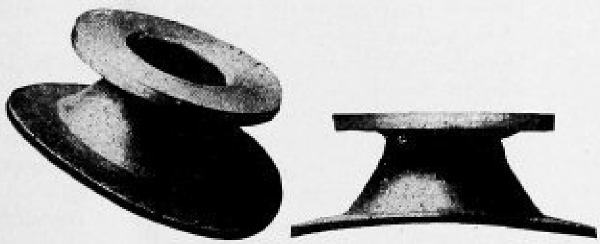
Referring again to the charts and photographs it will be observed that some represent comparatively small ingots or castings of steel and others much larger ingots, while some are thin in proportion to their width, and others have the width and thickness more nearly alike, and yet the same general characteristics run through all of them, so that after the main accumulation of impurities at or near the top is cut off there still remains a very considerable variation in these elements, which affect the tensile strength and ductility of the metal, this variation following largely the location in the finished piece corresponding to the location of the zone of gas cavities.

Chart 12 was made since my previous article was prepared from the tests made to further confirm the conclusions arrived at from the results shown in Chart 10, the samples in the case of Chart 11 having been taken to show the center line or axis of an ingot 16 inches square by about 40 inches long, and at the same time to show the results on corresponding levels on two opposite sides, these side samples being obtained by

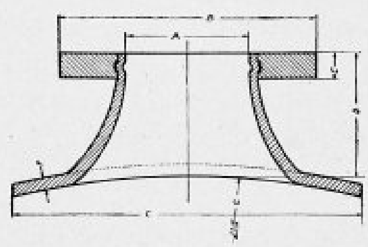
* From a paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

Horsley Pressed Steel Boiler Nozzle

ADVANTAGES are always apparent when comparing our pressed steel nozzles with any cast iron nozzle.



Our Horsley Pressed Steel Nozzles are many times stronger, lighter, and more easily fitted than any others. They not only will not break when rivets are being driven, but also effect a much greater saving at first cost to the boiler manufacturer. The upper flange is pressed from 1 ¼ inch flange steel and is bored and grooved. The body is pressed from 5-8 inch flange steel, and expanded into this groove under hydraulic pressure, and the flange is faced off true on a lathe, producing a joint which is fully guaranteed to be tight under 1500 pounds pressure.



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Segregation by agreement, I think, of all authorities upon the subject, occurs from two main causes: One is from expulsion by "selective freezing" of the steel; the steadily accumulating wall of solidified steel at the outer portion near the mold constantly expelling into the liquid portion the hardening elements or metalloids, such as carbide of iron, etc., and these elements, as the results of this, steadily increasing in percentage in the liquid metal. The other is from a tendency in these metalloids to float toward the top by reason of the difference in specific gravity, these metalloids being lighter than the pure iron, and consequently they seek the top.

It will be noticed that the thinner ingots show greater difference in hardness between top and bottom near the outer edges than the thicker and heavier ones; evidently caused by the quick chilling of the metal catching the hardening elements just as they were situated, and thus preventing them from separating out and floating into the unsound discard portion at the top.

It will also be noticed that in all sizes the outer skin of the metal, as it chills first against the mold, is very nearly uniform in its character, so that samples taken from all points equally distant from the outside surface will show practically the same physical and chemical properties, with the exception of the slight difference between the upper and lower portion as explained.

Steel with higher carbon, such as is used in rails, and steel treated with ferro-silicon and other similar materials, such as is used for steel castings, have a different character and seem to incline more to run to a pipe in the center, owing to the different behavior of the metal in the mold in process of cooling. These steels, as stated before, I am not sufficiently familiar with to say very much about and, consequently, have not brought them into this article; these general characteristics may or may not apply to them.

The steel when poured is very fluid, and is in constant motion and circulation in the mold, this movement thoroughly mixing the metal and causing a continued generation of gases which pass off through the molten steel and escape; at the same time there is forming against the mold a steadily increasing coating or wall of solidified steel. As the temperature falls, however, the molten steel becomes steadily less fluid until a stage is reached where the bubbles fail to pass off through it because of its increasing thickness of consistency, and are caught just at the one point as shown. This thickening of consistency also operates to prevent the further circulation of the steel, and, consequently, the further generation of gases; that portion lying inside of this zone of holes first becoming of a pasty nature and then solidifying practically all in one mass, so that at the same time circulation ceases, gas forming ceases, and segregation ceases.

From the examination of these charts it will be observed that the variations, necessarily occurring within any one plate of steel of any considerable size, are almost as great as the total range of test allowed in most of the current specifications, so that if the hardening elements in a piece of steel are sufficient to give the required tensile strength in the portion near the edge of the plate which is available for the test specimen, there will almost unavoidably be a very much higher range of tensile strength throughout a very considerable portion of the remainder of the plate, and which is the portion used in making the boiler.

It will also be noticed that while the higher portions in the plate give a higher showing in chemical analysis than the ladle test which is obtained from drillings from a little test ingot taken to represent, as nearly as may be, the average content of the steel in the large ladle, containing the whole melting of steel in the open hearth furnace—usually about 50 tons—yet there are some portions of the plate from which these metalloids have been expelled in the cooling process, which show a lower result than the test ingot, and yet the analysis of this test ingot must be the main dependence in the selection of the steel to determine its suitability to roll into a given product in order to produce the specified tensile strength and ductility; and this ladle test is the analysis usually specified to be taken as the indication of the quality of the steel in all standard specifications, analyses from the actual rolled piece, usually from the broken test-specimen, being used only as a check.

From our experience as makers of boiler steel, running back through a good many years, we can state that we seldom or never have had an unsatisfactory service reported from steel which is made good and soft, while we do have reports of unsatisfactory conditions, both in working into shape and in service, where the tensile strength is run up high and the steel is verging on to brittleness, and it is my firm belief that the boiler makers should act in conjunction with the makers of steel to discountenance a tendency, which is still manifest in some quarters, to run the tensile strength of the material away up in order to avoid extra weight or to secure greater steam pressures with the same weight of steel, thereby reducing the margin of safety very greatly, even though the greatest care be taken in working the steel into shape for the boilers, fitting, riveting, etc., while it is manifest that where any workmanship should be done without such extreme care the risk is still greater.

This is the more important in view of the facts above set forth that in the present state of the art of the manufacture of steel it seems practically impossible to avoid having in any plate of considerable size certain portions which contain a higher percentage of carbon, phosphorus and sulphur than the results of the test pieces cut from the edge would show; and it is this additional hardness and consequent lack of ductility which brings in the element of risk and reduces the margin of safety, and it will doubtless be manifest to all of us that, having knowledge of conditions that exist and which have such a bearing upon the safety to the public in the use of boilers, we should encourage such rules as will to the greatest practical extent result in the safest and most serviceable boilers we know how to produce.

The carbon, phosphorus and manganese are the elements most important for us to consider, as they are the ones which affect the strength and ductility while cold, and of these three the carbon and phosphorus are most important, because they are the ones which are likely to vary in proportion throughout the different parts of a large body of steel. The sulphur, while necessary to be considered for the working of the steel while hot, does not come so much into play in the ultimate safety of the boiler, because weaknesses caused by sulphur will probably always show up in the boiler maker's hands in flanging and other hot working, and the value of the material for service is very little impaired by any ordinary amounts of it, as it does not seem to affect the strength and ductility of the steel while cold or at ordinary service temperatures.

According to inquiries made by the *American Machinist* among locomotive builders, it is found that in nearly all cases stay-bolts for locomotive boilers are being made with the Whitworth thread. This is done for two reasons: Specifications for locomotives for foreign countries always mentioned Whitworth threads, and boiler makers fell into the habit of making their taps and dies with rounded points, so that they were practically getting Whitworth conditions. Even with the United States standard thread the stay-bolt top is very apt to become rounded on the top, as boiler sheets are often quite hard.

Boiler Explosions; Their Causes and Prevention*

BY S. F. JETER

The cause of steam boiler explosions are so varied that it will only be possible to mention the more prominent ones in this paper. Broadly speaking, there is one explanation for all boiler explosions; namely, the boiler, or some part of it, is too weak to withstand the strain brought upon it. However, there are many causes contributing to such weakness.

The public and many engineers assumed that most explosions are caused by some mysterious influence which cannot be foreseen or guarded against, but as an actual fact a definite cause can be given for most explosions of considerable violence. That a large percentage of boiler explosions are from causes that might have been foreseen and prevented, is a well-established fact.

The Hartford Steam Boiler Inspection and Insurance Company's business during the past forty-five years has been built upon this idea, and the company's success and low loss ratio have demonstrated its correctness. Public opinion is being aroused to the fact that many boiler explosions are preventable, as evidenced by the present agitation for laws governing the construction and operation of boilers. The lead of the city of Philadelphia has been followed and improved upon by the State of Massachusetts; Ohio and several municipal governments now have boiler laws patterned after those of Massachusetts, and similar action is being seriously considered by a number of other States and cities. I can speak from experience gained in the manufacture of boilers, and I am sure you will bear me out in the statement, that good laws on this subject, of uniform character, will be welcomed by the high-grade boiler manufacturer as a distinct aid tending to eliminate unfair competition.

The cause of boiler explosions which I will deal with first, because it is of particular interest to the manufacturer, is faulty design. Boilers are frequently constructed too weak for the pressure to be carried. This does not mean that the boiler will necessarily explode as soon as pressure is raised. Explosions from this cause usually occur after years of use, the overload on the parts having had time to gradually weaken them until they are no longer capable of resisting the excessive strain. Of course, a manufacturer has practically no control over the steam pressure to be used on a boiler after he has delivered it to the purchaser. However, if the manufacturer should stamp his name and the safe working pressure for which it was designed on each boiler built, it would act as a protection to his reputation in the event of excessive pressure being used. Proper inspection and fixing of pressures by experts is the logical remedy for explosions due to this cause.

A fault of design which often leads to an explosion is the adoption of a shape which tends to deform under pressure. In such cases, if the movement produced occurs in narrow limits along fixed lines, grooving or cracking is almost certain to result, finally causing an explosion, unless the defect is discovered before the structure has been weakened to the breaking point. The obvious remedy is to use shapes which internal pressure does not tend to change; and if this is impractical, to use such forms that the movement produced will occur over considerable areas and not be confined to narrow limits.

Improper reinforcements of opening has occasionally been the cause of boiler explosions. If the openings in boiler work were not generally of such moderate dimensions, this might be a more frequent cause of disaster. It may be well to say here that no definite information is available regarding the distribution of stresses around an opening in a cylinder when subjected to internal pressure; consequently, the design for the reinforcement of such openings is by rule of thumb.

A cause of boiler explosions, where the design is primarily responsible, is when the arrangement does not permit of accessibility for the inspection of all parts. This is especially so when the inaccessible parts are located where rapid deterioration is likely to occur. No portion of the boiler proper should rest directly on a foundation, or have any of its parts buried in earth or ashes.

A design which does not permit free circulation of water in all of its parts is liable to produce rapid internal corrosion; for unless a current is produced by the circulation sufficiently strong to remove all bubbles of air that may attach themselves to the surfaces, rapid corrosion is almost certain to ensue, which, if neglected, may result in an explosion. Air which is a mixture of about four parts of nitrogen to one of oxygen, together with very small quantities of other gases, dissolves to a certain extent in water. However, the oxygen, being more soluble than the nitrogen, dissolves more readily and the proportion of the gases found dissolved in the water are, roughly, one of oxygen to two of nitrogen, instead of in the proportions found in the air. When the dissolved air is liberated by the heat, the high percentage of oxygen causes the surface on which the bubbles may collect to be rapidly corroded. This accounts for the severe corrosion of vessels containing water which is merely heated without a strong circulation being produced.

A correct boiler design will provide uniform flexibility throughout. A stiff rigid part next to one which is flexible is a menace to safety if there is any tendency toward movement between the parts, either due to temperature changes or pressure.

Defective workmanship is responsible for some explosions. The barbarous practice of drifting rivet holes has doubtless contributed largely in the past to such accidents. The reputable manufacturer of to-day, however, will not knowingly permit such work.

Lack of properly flaring the tubes and nipples in water-tube boilers has frequently resulted in explosions. The Hartford Steam Boiler Inspection and Insurance Company has always advocated proper flaring, and sometimes manufacturers have taken issue with the company on this point. Experience, which has cost the insurance company many thousands of dollars, has fully demonstrated the correctness of their position in this matter. The safety of the joint between a tube and plate when expanded and flared, or merely expanded, is not a question of the relative strength of such connections newly made. When, for some reason connected with the operation of a boiler, a connection of this kind becomes loose due to a movement of the parts from expansion or vibration, together with the excessive weight sometimes sustained, the tube or nipple with a flared end is decidedly more safe than one which is merely expanded. The flared nipple usually gives warning of its looseness by leakage before it pulls out.

We all know from experience that the tendency is for employees to cover up mistakes in the shop. A manufacturer cannot guard his reputation from injury by this means too carefully. A loss of reputation for good work, after it has been well established, is many times more costly to the manufacturer in dollars and cents than the correction of errors before work leaves the shop.

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* A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

Defective material is sometimes the cause of boiler explosions, and the boiler manufacturer is largely dependent upon the producer of the material entering his product for protection in this respect. Nothing but material of the best quality should be specified for all parts of a boiler which are called upon to resist the strains produced by the pressure of steam, and every precaution should be exercised to see that such material is obtained.

Cast iron should never be used in any part of a boiler called upon to resist tensile strains. This is in thorough accord with your views on the subject, as expressed in your uniform boiler specifications.

A cause of explosions, which is particularly reprehensible because of its being preventable, is due to an owner's willingness to pit his judgment against more competent or conservative advice. Often boilers are known to be in need of repairs, but the work is put off to a more convenient season. A feed pump refused to start and, instead of fires being drawn as soon as the water reaches the lowest safe level, a chance is taken that it can be run a little longer. Pressures are sometimes carried higher than reasonable safety would permit, to avoid the expense of larger engines or better boilers. Boilers are forced beyond a reasonable duty for the heating surface they contain. This is a feature that must be reckoned with more in the future than it has been in the past. Many engineers are apparently trying to discover by experiment the limit to the rate of transfer of heat from fire to water through the medium of boiler tubes and plate. In order to show minimum investments necessary and other economies, resulting from high rates of driving, engineers are prone to advise overloads on both engines and boilers, and all seem to overlook the all-important question, "Is it safe?"

Boiler explosions are also the result of neglect or carelessness in operation. Scale and deposit are often allowed to collect in quantities that are dangerous. Connections to water columns are allowed to become stopped. Oil is permitted to enter the boiler with the feed water. Repairs to settings which may affect the safety of the boiler are neglected. Safety valves are not regularly tested to ascertain if they are in operating condition. Occasionally a boiler owner who discovers his safety valve leaking, with an eye blind to every consideration except the prevention of loss of steam, places a stop valve on the connection to the safety valve or plugs the outlet. A steam gage registers incorrectly and the engineer screws down on the safety valve in an endeavor to make the gage show the correct pressure. The pressure of steam is not sufficient to produce results desired with the machinery using it, and the safety valve is deliberately made imperative to overcome the difficulty. All of these conditions have been the cause of boiler explosions in the past, and they probably will continue to contribute their share in the future until the steam user is more thoroughly educated in the matter of the risk he runs by such carelessness.

Tube failures, which are chiefly confined to the watertube type of boiler, are a source of grave concern to the boiler insurance interest on account of the difficulty to guard against the usual failure of this kind by inspection. A defective weld usually does not show on the surface of the tube; and even where the surface indications would lead to suspicion, a large percentage of the tubes in watertube boilers are beyond the reach or vision of the inspector. The thorough inspection of tubes before they are placed in the boiler, while very unsatisfactory, even taken in connection with the mill test, is about the only protection possible against accidents due to defective tubes.

The seamless tube, of course, will prevent accidents due to defective welding, but tubes made by this process are not always of uniform thickness, and with the cold-drawn product there are apparently internal strains produced by the process of manufacture which sometimes cause the tubes to break when merely heated. If cold-drawn tubes are used for boiler purposes, the annealed stock should be obtained. Hot-drawn seamless tubes are meeting with considerable favor among engineers for boiler purposes. A considerable percentage of tube failures occurs without the slightest evidence as to their cause. A welded tube frequently breaks through the solid metal away from the weld, without being corroded or weakened in any way that may be detected by the eye, and without evidences of overheating. There must be some reason for such failures.

It is a fact that, while pressures and rates of driving have been remarkably increased during the past fifteen or twenty years, no increase in the thickness or strength of tubes has occurred. That the thicker tube is safer seems to have been demonstrated by a number of cases where heavy tubes have been put in place of those of standard gage at the recommendation of the Hartford Company, and tube troubles have ceased. Of course it can be contended that the theoretical factor of safety is higher on tubes even of standard thickness than on almost any other portion of the boiler. However, under operating conditions accompanying high rates of driving, is it not possible that there are decided fluctuations in the temperature of the material in the tubes? The rapid formation of steam bubbles removes for a certain interval of time the water protection from the inner surface of a tube; and the thinner the material, the higher will its temperature rise during a given time in which it is not protected. It is conceivable that the structure of the metal in a thin tube may be affected in time by this constant change in temperature until it gives out, while the thicker tube might not be affected to the same degree by this means.

This idea is only advanced as a possible explanation for some of the tube accidents which seem to defy definite causes being assigned for them.

The thicker material in the case of welded tubes will make more certain that the required strength is obtained in the weld, also surface imperfections in the material would not affect the strength to the same degree in the thick tube as it would in the lighter one.

The importance of the question of tube failures to the operator of boilers, as well as to the insurance interest, can be appreciated when I say, as I believe I can conservatively, that the toll of loss of life and limb exacted by such failures probably exceeds other classes of boiler accidents when the relative number of firetube and watertube boilers in use is considered.

Corrosion has been the cause of many serious explosions; but with boilers built accessible for inspection, explosions from this cause may be reduced to a minimum where the boilers are under the care of a competent inspection service.

A source of explosions, external to the boiler itself, but which has produced very serious disasters, is the improper arrangement of steam piping. It is very dangerous indeed to attempt to connect a boiler to a steam line where the piping is arranged so that water pockets may be formed. A water hammer is likely to result in such cases which may break the pipe connections, and this in turn may produce an explosion of the boiler itself.

A source of very disastrous explosions has been the prevalence of the hidden crack or so-called lap-seam crack. The cause of these defects is either the form of seam, poor material, improper shape of the joined ends of the sheet, or abuse of the material in the process of manufacture, or possibly a combination of some of these causes. That the form of seam alone is not the only factor is well demonstrated by the fact that all lap-seams do not fail in this manner, and also that some seams of the butt joint type have thus failed.

It is, of course, readily recognized that, with every precaution which can be taken, boiler explosions cannot be entirely eliminated, but their number may be lessened materially. A proper inquiry into all accidents of this kind by Government officials qualified and clothed with ample authority to get at all facts in each case, and the blame, if any, placed where it properly belongs, would tend to reduce the number of explosions materially. This is a feature we might profitably copy from our English cousins.

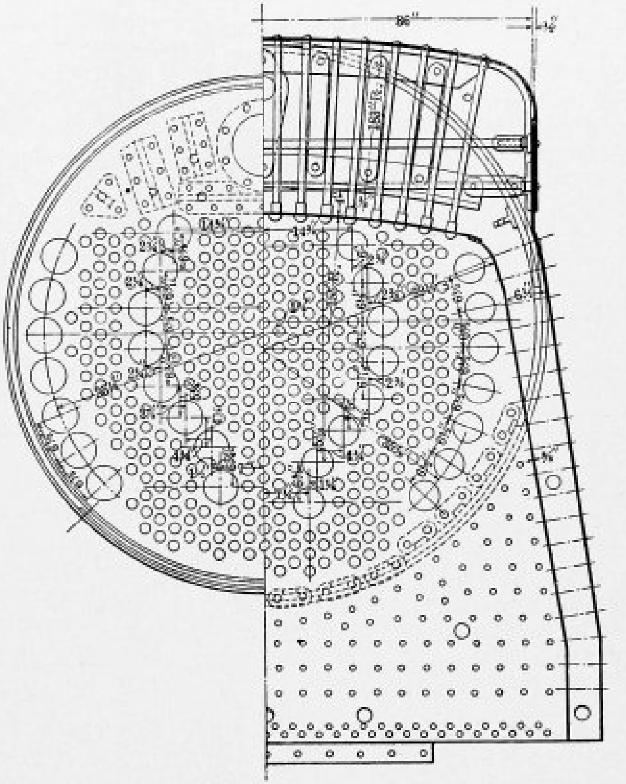
Mikado Locomotives for the Great Northern*

As our readers are well aware, the past year has shown a great revival of interest and a very general development of the 2-8-2 or Mikado type locomotives for freight service. This design has been continually enlarged and improved, greatly surpassing anything which was considered possible when it was practically abandoned four or five years ago, until it now occupies a position which, until a comparatively recent period, it was believed could be covered only by the Mallet type. The reason for this renewed lease of life will be found principally in the success of the high degree superheater which has so greatly increased boiler capacity as to permit a boiler of sufficient capacity per unit of weight to be mounted on four coupled drivers without exceeding a safe axle load, and enable the locomotive to deliver a very high ratio of its maximum tractive effort at moderately high speeds. In a recent discussion of the comparative merits of the consolidation and the Mikado type locomotive, it is pointed out that while the maximum theoretical tractive effort of the Mikado could be attained by the consolidated type, it is the sustained high tractive effort at high speed, which means boiler capacity, that is assured by the former.

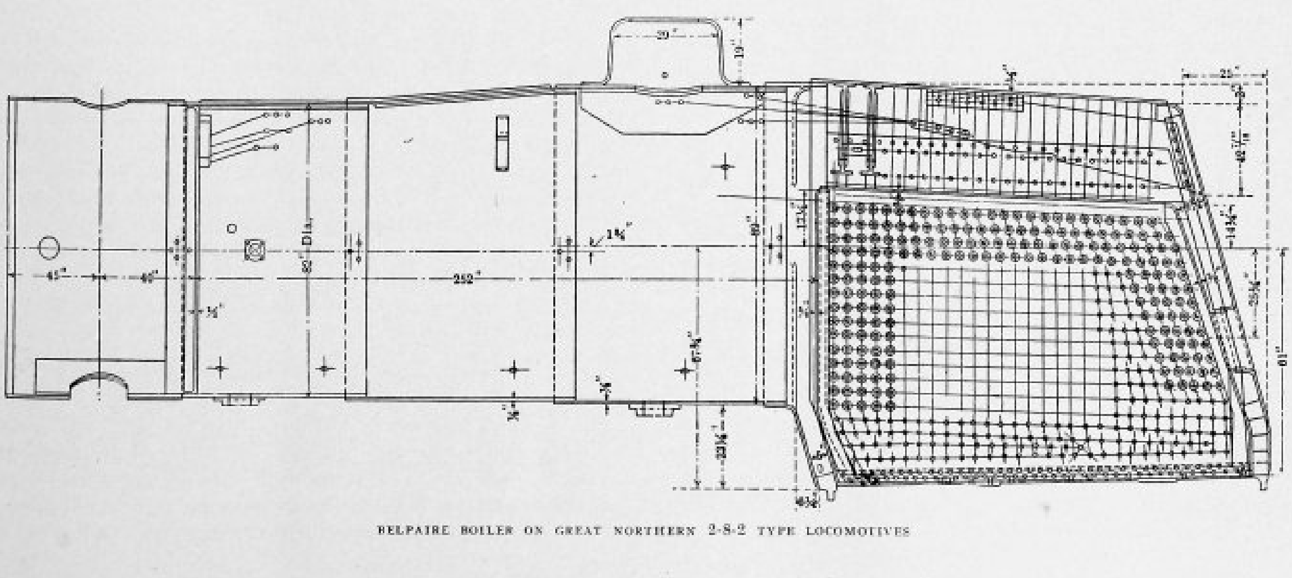
On the locomotives illustrated herewith, twenty of which were recently delivered by the Baldwin Locomotive Works, Philadelphia, Pa., to the Great Northern Railway, a boiler 82 inches in diameter at the front ring and 89 inches maximum diameter, having 21-foot flues, and a grate area of 78.2 square feet, has been applied. It is fitted with an Emerson high-degree superheater, having 1,060 square feet of heating surface, and the pressure has been reduced to 170 pounds. This boiler is of practically equivalent size, but is of greater capacity than the one applied to the 2-6-6-2 type locomotives, of which there are forty-five in service on this road. They were not fitted with superheaters, although a later order of the 2-6-8-0 type, considerably larger in size, were equipped with Emerson superheaters and also feed-water heaters.

In accordance with the Great Northern Railway Company's practice, the boiler is of the Belpaire type, and has both the crown sheet and outside roof sheets slightly arched. The water spaces at the mud-ring are 5 inches in width, increasing to 6½ inches at the sides and 8¼ inches in the back water leg. In one of the illustrations will be seen the arrangement and location of the 5½-inch tubes enclosing the superheater elements, there being thirty of them. It will be remembered that the Emerson superheater employs headers somewhat similar in shape and location to the ordinary steam pipes. An improvement has been made in this application, in that the saturated

* From *American Engineer and Railroad Journal.*



SECTION OF BOILER, SHOWING ARRANGEMENT OF SUPERHEATER TUBES

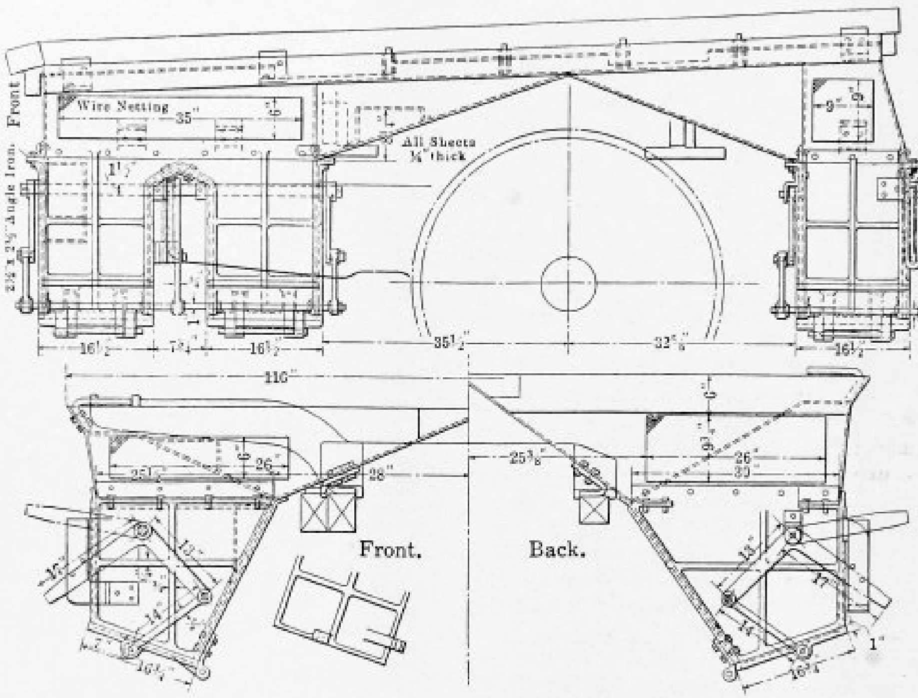


BELPAIRE BOILER ON GREAT NORTHERN 2-8-2 TYPE LOCOMOTIVES and superheated steam chambers are in separate castings, which are bolted together, leaving an air space between. The bolt holes are sufficiently large to permit of movement due to the different ratios of expansion of the two sections. These headers connect to the steam passages in the saddle in the usual manner, but a 5½-inch pipe connects the two passages below the header connection, thus permitting the equalization of pressure and allowing each cylinder to draw on both superheater sections for its supply.

A novelty is found in this design in connection with the ash-pan, which has six hoppers, all arranged to discharge outside the rail. The lower section of each of the hoppers is formed of cast iron plates and provided with a hinged door, the two forward ones being operated together from one gear, all operation being by hand. Details of this construction are clearly shown in the illustration. While this ash-pan probably does not have any greater capacity than one discharging between the rails, it very completely fulfills the requirements of the ash-pan law, as under no conceivable circumstances would a man have to get underneath the engine in cleaning it. It will be noted, however, that cinder pits having one rail on the outer wall of the pit would not be suitable for use with this pan.

In other particulars there is little of novelty in connection with the details of the design. The dimensions of the boiler are as follows:

Style	Belpaire
Working pressure	170 pounds
Outside diameter of first ring	82 inches
Firebox, length and width	117 by 96 inches
Firebox plate, thickness	⅜ by ⅝ inch
Firebox, water space	5 inches
Tubes, number and outside diameter	30—5½ inches; 326—2 inches
Tubes, length	21 feet
Heating surface, tubes	4,471 square feet
Heating surface, firebox	249 square feet
Heating surface, total	4,720 square feet
Superheater heating surface	1,060 square feet
Grate area	78.2 square feet
Center of boiler above rail	117 inches



SIX-HOPPER ASH-PAN OF NEW DESIGN

Figuring Strength of Boilers by Slmple Methods

Rules upon rules for determining the strength of boilers with their many exceptions and variations bewilder and confuse some of our best operating engineers, and in order to get straightened out I went back to first principles and thought out a method of my own, simple and not easily forgotten, so I present it herewith.

Considering a boiler 1 inch in diameter and a section 1 inch long with ½-inch plate the section area would be 1 square inch, and hence if the strength of the iron or steel is 50,000 pounds per square inch, 50,000 pounds would be required to burst it. If the boiler is 50 inches in diameter the bursting strength would be 1/50th of 50,000, or 1,000 pounds, and the safe working pressure would be 1/6 of that, or 160 pounds, provided there were no seams. A single riveted seam has only 50 percent of the strength of the plate and a double riveted seam 70 percent, consequently 83 pounds would be the working pressure for a single riveted boiler and 116 pounds for a double riveted boiler of the above dimensions.

Boilers of the same thickness and same number of rows of rivets, all made out of the same material, will vary in strength in proportion to their diameters. Thus the bursting strength of a boiler 1 inch in diameter with ½-inch plate would be 50,000 pounds; a 2-inch boiler, 25,000; 10-inch boiler, 5,000; 25-inch boiler, 2,000; 50-inch boiler, 1,000. If the above plate was only ¼ inch thick then the bursting pressures given above would be divided by 2. If the boilers were made of 1-inch plate the bursting pressures would be double that given above. In other words the strength of a boiler increases directly as the thickness of the plate.—George Gilford in *Practical Engineer.*

Boiler makers who have encountered difficulties in using the ordinary "old man," or knee brace, which is commonly used to brace up a ratchet drill or an electric drill, will be glad to know that a universal "old man" or universal drill brace has been devised which, it is claimed, will do this work in any position, and can be used to advantage wherever drilling is done in railroad shops, structural shops, boiler shops, etc.

Steel Rivets*

BY D. J. CHAMPION

Rivets are the most important articles you use. On their trustworthiness, life and property depend, and for this reason too much importance cannot be attached to guarding the quality, and looking after the workmanship in order to insure, as nearly as possible, perfection along these lines.

Improvements in the quality of rivets have kept pace with the improvements in the manufacture of steel, and excel them to some extent. Twenty years ago steel rivets were practically unknown, and the conservative boiler maker would throw his hands up in horror even at the mere mention of them. So great was the antipathy against them that one of the leading manufacturers, who was then successfully producing steel rivets, was afraid to call them by their proper name, "steel rivets," and sought to appease the prejudice against them by using the misnomer "semi-steel."

The word "steel" was formerly used to indicate hardness and brittleness; that is, it conveyed the idea of an unyielding metal, principally intended for razors, swords, chisels, plowshares, gun barrels, or other articles of like hardness that required a very good, strong, stiff material that would wear well. With the advent of basic open hearth steel, however, a metal was placed on the market that was a surprise even to the most skeptical. The metallurgist and the steel maker worked hand in hand to make this metal thoroughly reliable, and the result to-day is that good, soft, basic, open hearth steel cannot be surpassed for the manufacture of good rivets, or other articles requiring the maximum of strength and toughness. The great desideratum long sought for—namely, low sulphur and low phosphorus—was attainable for the first time by the use of this process of steel manufacture. So great have been the improvements in the manufacture of this steel, and so responsive under intelligent management have been the furnaces and rolling mills for the manufacture of it, that it is put on the market to-day as a very reliable product at a reasonable price.

For the enlightenment of those who still lean towards iron in preference to this steel, let it be said that this steel is over 99 percent pure iron and much more reliable for the production of rivets than the best Norway iron. This is not meant to convey the idea that good iron, either Norway or best charcoal bloom, has not its uses for certain purposes; for instance, where the action of the contents of a vessel has a tendency to oxidize the metal to such an extent that more is expected of the rivets than of the plates into which they are driven. But what I contend is that, for all other purposes where rivets are used, mild steel is superior to iron. Those who will recall their troubles of years past, when they used charcoal hammered iron for boiler plate and the best iron for rivets, can now appreciate the truthfulness of my assertions in regard to the improvements made in the manufacture of steel. Steel to-day, in the shape of boiler plate, bars, shapes or rivets, is ideal compared with the product put before the public twenty years ago. Failures in the use of it are now very rare. The steel maker knows how to make it, the workman understands better how to handle it, and there is no question but that their work will come up on final test to their highest expectations. In line with the progress of the age in which we live, more and more is expected of every piece of power machinery manufactured; and if it were not for the improvements made in the manufacture of steel, it would be a physical impossibility to accomplish what we are accomplishing to-day.

A structure is no stronger than its weakest member, and this applies to the rivets in a structure in an emphasized sense. Did you ever stop to consider that rivets, of all the articles you use, are often tested to the death, and even then are expected to stand up and fill their place in the structure just as well as the plates into which they were driven, though these plates have not been heated or hammered, or treated one-quarter as harshly as the rivets that hold them together? In other words, to use a homely expression, good rivets are expected to be "fool proof," and if not "fool proof" they are often condemned. Would any of you tolerate your flange turner to hammer on a plate when it is blue? Yet very frequently you allow your rivet drivers to hammer on rivets until they are "black and blue," and condemn them if unfortunately the heads come off.

Rivet making, to use the expression of one of our worthy members, is an art, and a few of us have shown a disposition to acquire that art and work faithfully to gain our ambitions along these lines. Suffice it to say that if "Eternal vigilance be the price of success," then the rivet field offers ample opportunities to the painstaking and ambitious. When I recall the difficulties that presented themselves in putting on the market a rivet above criticism, I heartily agree with the member referred to, that the making of satisfactory rivets is an art, and not a lost art either. The gentleman to whom I refer enjoys the satisfaction of driving thousands of rivets every year, and I have his own statement that he is never obliged to calk a single rivet.

Too much importance must not be placed on the very interesting but misleading test of nicking and bending. It is a test intended for iron, not steel. Good iron is fibrous in its structure and will stand the test admirably, whereas steel may be of a granular structure and consequently should not be expected to stand this test like iron. If you should be in doubt about the superiority of one steel rivet over another, and you are inclined to test out the rivet by nicking and bending, I would suggest that you subject the two rivets to be compared to a heat suitable for driving, and then allow them to cool until both are entirely cold. Then nick and bend and you will find that the good rivet will show a good, clean fracture, free from crystallization; but it will not bend and show a coarsely fibrous fracture like iron. The nicking and bending test should never be used on a steel rivet to show fibre, for the structure of a good steel rivet may be finely granular instead of fibrous. Fine fibrous structure is, of course, noticeable in a steel bar of small diameter after coming from the rolls. At this stage the bar, under the nicking and bending test, would bend flat on itself without breaking and show a finely fibrous structure. But we should not expect to get this result after the double heating which must be given the bar in order to make the rivet. The United States Government realizes this fact and does not require rivets for its use to stand the nicking and bending test. If made at all, it is only to show the appearance of the fracture.

Under the caption of "Experiences," I am led to reproduce here a few suggestions which I consider of sufficient merit to have them copyrighted. They are as follows:

1. Hold some reliable maker responsible for the quality and workmanship of the rivets you drive.

2. Where the holes are not reamed, see that inside surfaces of the holes are parallel to each other without undue overlapping.

3. Heat your rivets intelligently, grading the degree of heat

*A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

to conform to the work you are doing, allowing hand-driven rivets to come to an almost white heat; pneumatic-driven rivets to come to a bright cherry red; and hydraluic-driven rivets to a dull cherry red; bearing in mind at all times the amount of pressure your machine is capable of putting on the rivets at the point of upset, and regulating the heat accordingly—the lower the heat, the greater the pressure, relaxing the pressure when the rivet is cold, or nearly so. Such rivets will fill the holes and avoid undue shrinking, and possibly calking. When high-pressure work is being riveted, ream the holes 1/32-inch full only, as tighter work can then be done.

4. Never continue hammering (on either end of the rivet) until it is blue.

5. Never try to fill a hole with a rivet smaller than the regular diameter required for such hole, which in all good work is 1/32-inch larger, bearing in mind that steel expanded by compression (as in the case of a rivet shank expanded to fill the hole that is more than 1/16-inch larger) is materially weakened in all its qualities of strength. Therefore, the closer the fit, the tighter and stronger the joint.

6. Never use heavy pneumatic tools on small rivets. In other words, never use a tool out of proportion to the size of the rivet.

7. Never drive a cold-made rivet cold without first annealing.

8. Never introduce a high-pressure blast into your rivet-heating furnace unless you break the flame by a fire wall, and even then a graduating valve should be used, reducing the pressure so as not to be over fifteen pounds, bearing in mind that only sufficient rivets be placed in the fire as can be conveniently handled by the driver without allowing them to soak too long, or becoming scaled.

9. Never allow your rivets to soak in the fire, either during the noon hour or over night. If a cessation of work is contemplated, draw them out of the fire, but avoid replacing them in the fire. If they have had too much heat previous, use new ones.

10. Never pass up to the driver a rivet showing that the metal therein started to melt. Such a rivet will cause trouble ultimately, as it is liable to remain loose in the hole, or lose its head if calking has to be done.

If you follow out these suggestions faithfully, you will never have trouble with good steel rivets.

During the past forty years we have made wonderful improvements in the manufacture of steel, and we doubt if history can produce a record anything like its equal. When Kelly, the inventor, sat before his father's melting furnace, and discovered for the first time how forced air could be utilized in the manufacture of iron, he opened to the world the possibilities of this essential and wonderful metal. Since then we have seen one improvement after another, until today we consider our progress well-nigh perfect. But we must not rest contented here, feeling that perfection has been reached, as we all realize history repeats itself; and if history repeats itself as regards the manufacture of steel as rapidly during the next forty years as during the past forty years, it will be difficult to conceive just where we shall land. When we consider the improvements in steel in our present day, made possible by the introduction of vanadium, nickel, chrome, manganese, etc., as alloys, we find it difficult to even attempt to portray its possibilities and still be considered entirely normal. What with lap welding, electric welding, acetylene welding and lock bar joining, to say nothing of the celebrated Diesel engine, we are led to ask what shall become of the necessity of the riveted joint, but we must pacify ourselves with the thought that at every stage of progress we should find ourselves perfectly conscious of the improvements being made, and none of us should be found lax in our determination to keep abreast of the times, and determine to be able to give as good an account of ourselves when the time comes.

WRECKAGE CAUSED BY A LOCOMOTIVE BOILER EXPLOSION ON THE SOUTHERN PACIFIC

Disastrous Boiler Explosion

The photograph shown herewith is a view of the wreckage caused by the explosion of a passenger locomotive in the terminal yards of the Southern Pacific Railroad at San Antonio, Tex., on March 18. This accident killed twenty-six men outright and seriously injured many others. Most of the men killed were strike breakers employed in the shops of the company, situated close to where the explosion took place. The cause for the explosion has not been ascertained.

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Outside of the active members of the American Boiler Manufacturers' Association few seem to realize the importance of this society, or what it has accomplished in the development of the boiler making trade. It is an organization which every boiler making concern in the country should be affiliated with, not only by holding a membership in the society, but also by having a representative present at all its meetings who can take an active part in its work. The association is by no means a new one; its proceedings cover a period of over twenty-four years, and during that time many of the most important questions concerning design, construction and maintenance of steam boilers have been discussed—questions that are of vital interest to everyone engaged in that trade and which are not taken up in detail by any other technical or commercial organization in the country. The opinions, criticisms and endorsements of the body as a whole and of its individual members expressed in its proceedings have a decided weight in guiding the technical and commercial trend of the boiler making industry. To find that only a small percentage of possible members are enrolled in the association and that a still smaller percentage of this number attend the meetings and take an active part in its proceedings, which are so excellently conducted for the profit and entertainment of the members and their guests, would be discouraging if it were not for the vigorous and efficient campaign which is at present being carried on by the staunch supporters of the association to increase its membership and usefulness. It should not be forgotten that besides the boiler manufacturers there is also an associate organization of the supply men, whose interests are mutual with those of the boiler manufacturers, and to them much credit is due for their willing assistance at the annual conventions. They have been responsible for the entertainment features at the conventions and have furnished many papers of interest for discussion at these meetings. In view of the combined efforts of the manufacturers and supply men, we hope that before the next convention, which will mark the silver anniversary of the association, the increase in membership and activities of the association will far exceed the standard which is confidently expected.

Mention is made elsewhere in this issue of the disastrous explosion of a Southern Pacific locomotive boiler at San Antonio, Tex. An investigation of this explosion has since been conducted under the auspices of the Interstate Commerce Commission and the Texas Railroad Commission, sanctioned and aided by the Southern Pacific Railroad. Voluminous testimony was taken, although it is unlikely that any report of the findings will be made public unless the testimony should be submitted to the Legislature at its next regular session. From what information can be obtained, however, it seems that the whole trend of the testimony shows that the explosion was wholly accidental. One explanation which is offered is that the explosion was caused by an excess pressure of steam, due to the safety valve being screwed down. This valve was found in such condition after the explosion, and it is said that the testimony showed that the valve was screwed down by an employee of the railroad by order of the roundhouse foreman, as the locomotive was being made ready for its run. The man who obeyed this order was still on the engine when the explosion occurred and was among those who were killed. Other parts of the boiler showed that there were no weaknesses. Some of the bolts and braces supporting the boiler were not in good condition, but the explosion has not been attributed to their condition.

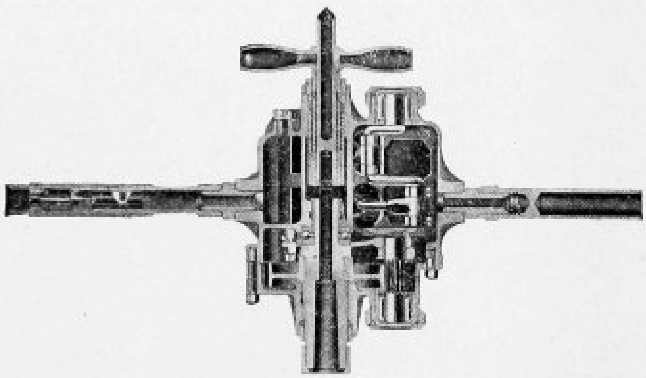
If the above report is true, although in this enlightened age it does not seem plausible, we can only raise a vigorous and oft-repeated protest against anyone having anything to do with a boiler safety valve who does not realize the danger attending thereto.

New Improved Engineering Specialties for Boiler-Making

Thor Roller Bearing Air Drills

The Independent Pneumatic Tool Company, Chicago, Ill., has recently placed a new line of portable drilling machines on the market, known as the Thor Roller Bearing Piston Air Drills.

These machines possess the same general features which were used so successfully in former types of Thor drills, such as Corliss valves, telescopic screw-feed, removable crank chamber plate, and large air chamber. The size of the spindle in most cases has been increased, but the most radical improvement is in the crank shaft bearings, connecting rods, eccentrics and eccentric straps. The crank shaft has been greatly strengthened, and anti-friction roller bearings are provided for same. The rollers are of ample length and



diameter and are retained in a machined brass cage. The bushings have a slip fit into the casing and are hardened and ground. The crank shaft has rounded ends and end thrust against a hardened plate, which reduces friction.

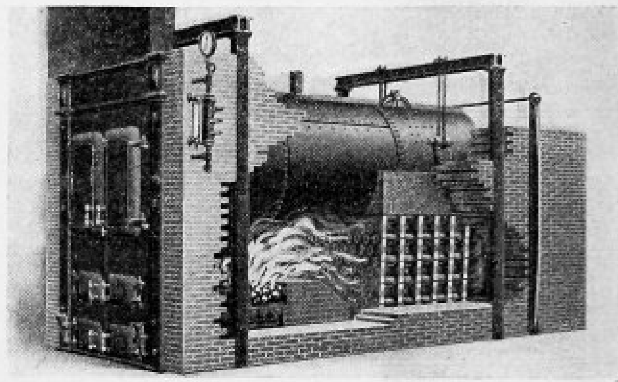
On account of the increased size of the crank shaft and ample size of rollers, the center bearing is dispensed with. The eccentric is smaller in diameter, and being mounted on the crank shaft still further reduces friction.

The toggle and connecting rod used in former types have been replaced with a one-piece connecting rod similar to that used so successfully in the Thor Numbers 8 and 9, close corner drills. Roller bearings are also provided for the idler or planet gears in the compound drills, and an improved shifter mechanism is used on all two-speed machines. The accompanying illustration shows this drill with roller bearings on each end of the crank shaft and one-piece connecting rod.

A Furnace Gas Consumer

The furnace gas consumer shown in the illustration consists of a series of refractory tubes set in the line of draft at or near the bridge wall in such a manner that the gases arising from the primary combustion of the fuel in the furnace pass through them before reaching the boiler tubes. These tubes are supported in place by blocks of an appropriate shape and the tubes are placed end to end in five or six lengths. As the passages through the tubes have an aggregate area equal to or greater than the area through the boiler flues, the flow of the gases is not impeded. Further, as the tubes form continuous passages from end to end accumulations of dust are easily blown out. No changes are required to the boiler foundations, the tubes utilizing the space hitherto wasted behind the bridge wall.

It is well known that smokeless combustion can be obtained in a boiler furnace, provided sufficient air is supplied to the furnace in such a manner that a sufficiently high temperature is maintained and reaches the gases from the fuel. It is claimed that this gas consumer accomplishes this purpose, and, furthermore, that the refractory tubes retain sufficient heat to heat the distilled gases and the air for their combustion within the tubes during the short period after each firing when unburned gases are given off from the fuel bed. The gas consumer thus utilizes as fuel that part of the unburned gases which in ordinary furnace operation escapes unconsumed and unutilized at the start. The more complete combustion of fuel creates, however, more heat, and the ability to burn the fuel with a smaller excess of air is even more advantageous. By promoting better combustion with less air better economy is obtained.



By installing the refractory tubes it is claimed that the heat radiating value of the fuel bed can be utilized without detriment to combustion, since the gases are consumed while passing through the refractory tubes. The bed of tubes thus become an efficient means of radiation, as the tubes are at all times at red or white heat, and the part of the boiler lying just above them is heated by radiation in just the same manner as that part of the surface lying above the grate is heated by radiation from the incandescent fuel. This material addition to the heat-absorbing capacity of the boiler naturally results in better boiler efficiency, since less heat remains to be absorbed from the gases by the boiler tubes; that is, adding a gas consumer is equivalent, as far as regards efficiency, to adding a large amount of boiler heating surface. The gases will escape to the chimney at a lower temperature, indicating higher efficiency of heat absorption. This saving is an advantage to the higher efficiency due to better combustion.

The general arrangement of construction of this device is shown in the illustration. The consumer is manufactured by the Furnace Gas Consumer Company, of Matteawan, N. Y.

The Byrd Tube Welder.

This machine consists simply of an upright stand with a large, round horizontal hole through the top, into which is securely fastened a hollow cast iron mandrel, having an angular space for circulating water within itself. Revolving upon this are two heads, one of which remains in the same vertical plane at all times, and to which the roller arms are fitted. These roller arms pass through holes in the second head, which is arranged to slide along this mandrel, and in so doing closes the arms together, thereby pressing the rollers upon the tube, or separates the roller when the weld is completed. The movement of the outside head is effected by means of a small air cylinder on the rear side of pedestal casting with the necessary gearing.

The machine may be arranged for belt drive by simply extending the pinion shaft a sufficient distance back of the pedestal to permit of a tight and loose pulley being applied, or by direct-connected electric motor mounted upon a bracket, in which case a 5-horsepower motor is required, and the roller heads should revolve at about 25 revolutions per minute.

By changing the rollers this machine, it is claimed, will perfectly weld tubes varying from 1½ to 5 inches outside diameter, and the Canadian Pacific Railway are welding superheater fire tubes for locomotives which are 5 inches in diameter and No. 8 gage without scalping ends.

For the convenience of the operator the air supplied to the compression cylinder is usually led to a point close to the operator's foot beneath the floor, and a small treadle arranged to act upon the valve spindle in such a way as to admit air to the cylinders when the operator presses on the treadle and the supply is shut off, and the air in the cylinder exhausted when the operator removes his foot.

The welding capacity of the machine is entirely limited by the length of time necessary to heat tubes to the welding point, as the welding process itself is performed in less than five seconds on an average.

Communications of Interest from Practical Boiler Makers

Flexible Stay-Bolts

In looking over some of the old journals I have come across an article on breakage of stay-bolts, by B. E. D. Stafford. There is no doubt that what Mr. Stafford says regarding the flexible or adjustable stay-bolt is quite true, and I think that much more can be said on the same subject from the point of view of a practicable boiler maker.

Having had some experience with various kinds of flexible stay-bolts, I would like to give your readers a little of that experience.

There is no doubt about the fact that the flexible stay-bolt properly installed overcomes breakages, and no one knows better than the old-time boiler maker the meaning of broken bolts, the hard, laborious work of removing them before the coming of the air drill and other labor-saving machines. Many a good man has lost an eye by caping out stay-bolts, and I think that we all ought to hail with joy the day when the flexible stay-bolt will be the only bolt used.

Examinations of flexible stay-bolts are made about every fifteen or eighteen months, when lagging and jackets are removed, but should it be necessary to test them oftener it can be done in the usual way while the boiler has at least 100 pounds of steam on—if broken they will give the same sound as a broken, rigid bolt.

Before removing the caps for examination soak them well with carbon oil; this will loosen any dirt that may have gathered around the sleeve, also find its way into the threads; then with a socket wrench about 36 inches long remove the cap, tap the head of the bolt, and if broken it will drop out. Before replacing the cap, clean all dirt from the cap and head of the bolt. Then put a mixture of lard oil and graphite on the head of the bolt and the inside of the cap, and replace, but do not put too much pressure on—enough to make it tight is all that is required. Should any of the caps be hard to remove, hold the flame of a torch under it until it is quite warm and it can be easily removed.

Should you, for any cause, have to remove any flexible bolts, first remove the caps, then cut off the heads on the firebox side, carefully center and drill with a ¾-inch drill, then with a punch you may drive the bolt out through the sleeve without damaging the thread or sleeve. It is possible to replace a bolt of the same size as the one removed. If this cannot be done tap the hole 1/16 inch larger, being careful that you do not cut a thread in the sleeve.

It is not advisable to replace bolts more than 1/16 inch larger than the original bolt, without renewing the sleeve also, for one fitted to the larger size. Fit your bolts so that they will pull into the bearing with the tool furnished for that purpose, and upon no account use a Stilson wrench upon the head of the bolt, or upon the point where it is through the inside sheet. I have seen this done and sanctioned by a foreman.

In cutting off the bolt have your helper hold a sledge under the bolt while it is being cut off with a very thin chisel. Give the bolt one-half turn back; this will free the head from the bearing of the sleeve and give it room to adjust itself while working. Do not make the mistake of cutting flexible bolts with a chisel bar and maul. If you do you will break the sleeve.

In riveting flexible stay-bolts see that the bucking-up tool is well screwed on the sleeve and that there is room for the ram to work freely; if it is not you are liable to break the sleeve when the bolt is struck. Use a light hammer and remember that there is thread only on one side of the bolt, and light blows will do the work better than heavy ones; also see that the helper does not bring his sledge or bar back on the bucking-up tool, but that he comes back gently; in fact, the whole job, from beginning to end, is one of care, and should be entrusted to none but the best of workmen.

It is a regrettable fact that many of our foremen do not realize the advantages of the flexible bolt. In speaking to one recently, he cut me off quite short with "To h—l with them; if I had my way there would be no flexible bolts used." Having examined a large number of engines with installations of some 400 flexible bolts, I am glad to say that I have not found one broken or one rigid one in the entire lot. I am satisfied that had they been rigid bolts, there would have been a large number of broken ones in the time these engines have been in service.

Flex. Ible.

Pittsburg, Pa.

A Word of Encouragement to Apprentices

How often we hear young men say, "What's the use of trying to get ahead, anyway?" Let me say right here that for every hour I have spent in studying and trying to better myself I have received it back twofold.

To begin with, I started in the boiler making industry as a heater boy, and I used to hear the layer out talk about the constant 3.1416, and watch him develop patterns for the different forms of work that came along. It was all Greek to me. I used to think then if I only could learn to do that it would be as high as I would care to go.

So I got hold of some books on pattern drawing and practical geometry and started in. I used to study until 12 and 1 o'clock in the night, and layout the patterns on paper, then form them up and see if they resembled the object, and in this way I became quite proficient on paper. But when I came to put my knowledge to practical use, I was lost, as I did not know how to make the necessary allowances. But I soon mastered this and got an opportunity at the laying-out bench, passing by men who had been in the shop for over thirty years, men who had become contented with the old rut and were satisfied to leave well enough alone.

From laying out I advanced to foreman, and I thought, "Well, now, I've reached the height of my ambition." But I found the foreman's position inspired me to become manager and owner. And I am glad to say to-day, I am now manager and owner of my own shop. But let me say that the road was by no means an easy one, and what one man has done another can do. It is by reading such articles as those written by F. Ormer Boy in The Boiler Maker, and others, that inspires a young man to better his condition.

I also agree with J. T. Bradbury, that an apprentice, after serving his time, should go around to other shops.

Providence, R. I. Frank T. Saxe.

Design of a Beam

In answer to correspondent C. G. T's letter in the October issue of The Boiler Maker, *re* the design of a beam, I would offer the following explanation: We will assume a factor of safety of 4, which C. G. T. will be able to alter to suit his requirements.

Let us, for an example, neglect the stiffening braces for the moment and take it that it is a simple beam loaded in the center with 70,000 pounds, or 31.25 tons in the first instance, as in Fig. 1, and loaded with two weights of 35,000 pounds, or 15.625 tons in the second instance, as in Fig. 2.

The first thing which we have to do is to find the reactions or supporting forces at the ends of the beam. Since the beam

Fig. 1

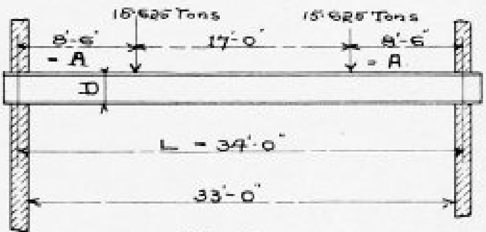


Fig 2

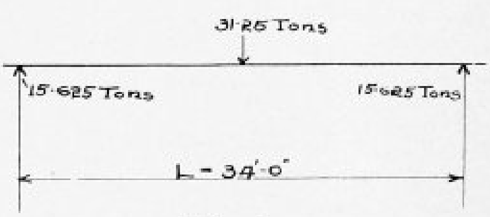


Fig 3

is symmetrically loaded, the downward forces at the ends, or in other words the upward reactions, will be half the load in both cases, or

$$\frac{31.25}{2} = 15.625 \text{ tons.}$$

The loads and reactions are shown in Fig. 3, the latter being the same for Fig. 1 and Fig. 2.

Let W = load on beam in tons.

L = span of beam in inches, 34′ 0″ × 12 = 408 inches.

$B\,M$ = bending moment in ton inches.

A = distance in feet.

a = same distance in inches.

I = moment of inertia of section.

Y = half depth of beam D (Fig. 1).

F = allowable working stress in tension or compression. The ultimate strength of steel at 28 tons per square inch gives us $F = \frac{28}{4} =$ 7 tons per square inch.

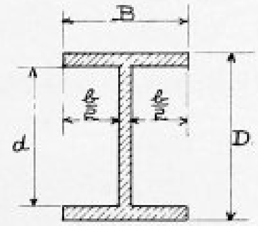


Fig 4

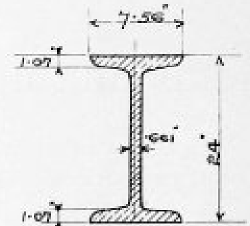


Fig 5

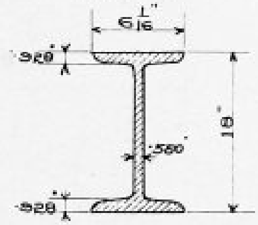


Fig 6

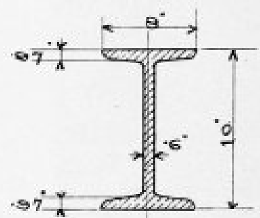


Fig 10

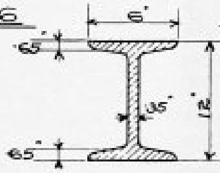


Fig 12

$$Z = \text{section modulus} = \frac{B\,D^3 - b\,d^3}{6\,D} \text{ (see Fig. 4).}$$

$$B\,M = \frac{W\,L}{4} \qquad (1)$$

$$\frac{31.25 \times 408}{4} = 3187.5 \text{ ton inches for Fig. 1.}$$

$$B\,M = \frac{W\,a}{2} = 6\,W\,A \qquad (2)$$

$= 6 \times 31.25 \times 8.5 = 1593.75$ ton inches for Fig. 2. As C. G. T. does not give a position for the two loads of 35,000 pounds, I have taken them as being at one-quarter the span.

The well-known formula for beams is

$$F = \frac{B\,M \times Y}{I} \qquad (3)$$

Now the moment of inertia for a joist, as in Fig. 4, is

$$\frac{B\,D^3 - b\,d^3}{12} = I \qquad (4)$$

Combining (3) with (4) $\left(\text{as } Y = \frac{D}{2}\right)$ we get

$$F = \frac{B\,M \times \frac{D}{2}}{\frac{B\,D^3 - b\,d^3}{12}} = \frac{B\,M}{\frac{B\,D^3 - b\,d^3}{6\,D}} = \frac{B\,M}{Z} = F$$

Transposing $\frac{B\,M}{F} = \frac{B\,D^3 - b\,d^3}{6\,D} = Z$ (5)

So that for Fig. 1 we require a section of beam which has a Z of $\frac{3187.5}{7}$ = say 455.357.

As we are using two beams side by side the section modulus will be $\frac{455.357}{2} = 227.678$ for each girder. It will be found that the section given in Fig. 5 will satisfy the requirements, as the $Z = 227.11$.

And for Fig. 2 $Z = \frac{1593.75}{7} = 227.678$ for both girders, and

Z for one girder $= \frac{227.678}{2} = 113.839$, or just half that of the case in Fig. 1.

A girder section as in Fig. 6 will satisfy the requirements of the case, as the $Z = 115.2$.

We will now investigate what effect the bar bracing will have on the strength of the beam.

The section of a 2-inch diameter bar is 3.1416 square inches, and at 7 tons per square inch we can put 3.1416 × 7, or 21.99, tons pull on same. If we fixed the bracing on the beam before either applying the load or fixing up in position, and tightened up the brace until there was 21.99 tons stress in it, and assuming that the angle between the top of beam and the braces to be 30 degrees, we should produce an upward thrust in the center of 2 sin 30 degrees × 21.99 = 21.99 tons, and a force of 10.995 tons in the opposite direction at either end, as in the line diagram of Fig. 7. Then Fig. 8 gives the forces which are acting on the beam when it is in position and has a load of 31.25 tons at the center. Subtracting the upward and downward forces, we get in Fig. 9 the forces which are tending to bend the beam.

Then $B\,M = \frac{W\,L}{4} = \frac{9.26 \times 408}{4} = 944.52$ ton inches,

and $Z = \frac{944.52}{7} = 134.88$ for the two girders, and one girder will require a Z of $\frac{134.88}{2} = 67.44$.

The nearest "British Standard" beam would be as in Fig. 10, and which has a Z of 69.01. Two of these placed side by side would answer the requirements.

If, instead of a central load of 31.25 tons, we have the two loads of 15.625 tons placed one-quarter the way along the beam, we shall get the diagram of Fig. 11, and the bending moment is 102 inches × 15.625 — 204 inches × (15.625 — 10.995) = 1595 — 945 = 650 ton inches, and $Z = \frac{650}{7} =$ 92.85 for the two girders, and the Z for each girder will have to be at least $\frac{92.85}{2} = 46.425$. The nearest "British Standard" section that we could use would be two girders of the section shown in Fig. 12, which has a Z of 47.87 each.

It will be noticed that the last example has the advantage of requiring the lightest section of beam. It should also be noticed that in the above the weight of the girder itself has been neglected, but it should really be included in the weight which has to be supported.

In conclusion, if we placed the braces so that the ends were 8 inches from the ends of girder, we should get two extra downward forces, which we should have to take into account and which would necessitate a greater section in the beam, as it would have to be made correspondingly stronger. As I am afraid I have already taken up a lot of valuable space, and

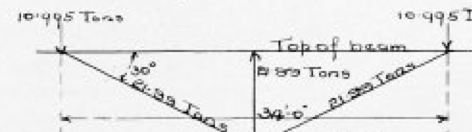


Fig 7

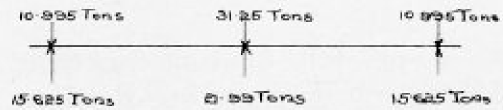


Fig 8

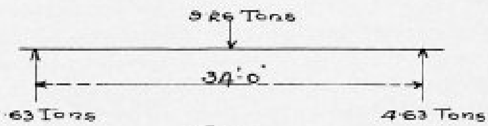


Fig 9

Fig 11.

since there is nothing to be gained by putting the bracing as suggested, I will not enter into details, although I will give them later on if C. G. T. requires them.

With reference to the bearing plates, etc., it is quite safe to allow a stress of 1,000 pounds per square inch on the wall, provided same is in good condition.

As we have 35,000 pounds on each wall, we shall require to have a bearing of $\frac{35,000}{1,000} = 35$ square inches at least.

Considering the last case, in which we use the 12-inch by 6-inch joist, and assuming that they pass right through the wall, we have, roughly speaking, 6 × 2 × 13 = 156 square inches of bearing area, so that if C. G. T. puts a cast iron plate a little larger than is actually required for the two joists to rest upon, and makes it about 1 inch or 1¼ inches thick, he will be on the safe side. The ends of joists should be built into the walls. I trust that this explanation will help my fellow reader over his difficulty. Francis A. Garrett.

Lincoln, England.

A Little Talk

In my experiences as a layer-out and foreman, I have very often met with the foremen and layers out who very strongly insisted that in the layouts of all work consisting of inside and outside circular courses of plate work you should have an additional allowance to the neutral circumference of the outside ring, or vice versa, a deduction should be made from the neutral circumference of the smaller ring, the addition or deduction being from ⅛ to ½ inch, and at times even exceeding ½ inch.

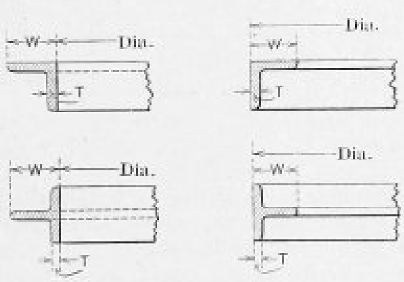
This performance is not at all correct, and should not be permitted. The majority of boiler makers and layers out who employ this method have, no doubt, been accustomed to having their work fitted up by an incompetent workman, hence the necessity of this guesswork. A competent fitter-up needs but the neutral circumference of any two plates to make a good job, and this is the correct circumference for the layer-out to employ in his developments. The right way to do things is the correct way, and this guesswork should be eliminated.

Furthermore, one is more sure of retaining the services of a good mechanic and conscientious fitter-up than he is of retaining one who, on the other hand, has exercised every possible effort to "lay up that gap," and then, after all, seen *his* work openly condemned on account of someone else's poor judgment and guesswork. J. F. H.

Exact Rules for Finding the Lengths of Angles and Tees Before Bending to Circular Form

There are, as I note from reading my BOILER MAKER, many boiler makers and layer outs who do not seem to have an accurate rule for bending angles and tees, i. e. to ascertain the accurate length of the bars previous to bending or rolling to a given diameter.

I have been laying out for the past twelve years mostly contract work, where angles and tees are handled equally as



often as plates, and beg to submit to you for publication the following, which I have used successfully, and which proves to be very exact:

Angle—Flange out:

$$\text{Circumference} = [\text{Dia.} + (\tfrac{1}{3} W + T)] \times 3.1416.$$

Angle—Flange in:

$$\text{Circumference} = [\text{Dia.} - (\tfrac{1}{3} W + T)] \times 3.1416.$$

Tee—Flange out:

$$\text{Circumference} = \left(\text{Dia.} + \frac{W + T}{4}\right) \times 3.1416.$$

Tee—Flange in:

$$\text{Circumference} = \left(\text{Dia.} - \frac{W + T}{6}\right) \times 3.1416.$$

The above rules will give the exact length of the bar before being bent. This is, however, a *net* length, meaning a *butt* joint.

For welding, the operator may allow as much more material as he is in the habit of allowing on similar work. In this case, I usually allow approximately ⅜ of an inch.

Albany, N. Y. JOS. F. HAVLAK.

Talks to Young Boiler Makers

In writing about heat I have struck a very interesting subject for boiler makers. Of course the main thing in boiler making is the actual work and then the material. I have already said that no one can learn hand skill from words. If you read a thousand books as thick as a year's volume of THE BOILER MAKER you would knock just as much skin off your knuckles as if you had not read them, and it would hurt just as much, and make you as mad. To know just how much sulphur and carbon there is in a plate of steel will not help you to chip straight. It does help to know that if you have a lot of rivets that crack that you can anneal them by heating to a dull red and covering them with charcoal and letting them cool; such knowledge will help you out on a hurry job.

It is an advantage to know something about heat and how it acts on the material that we see about boiler shops. It is not very interesting to know that gold melts at about 2,000 degrees F., as my experience has shown very little of that metal where boilers are made, but I give a short list of materials that you do find about you, and if you remember it you won't try to melt babbitt in a lead ladle.

A very clever man, whose name I think was Schmidt, which is the Dutch way of spelling Smith, discovered what is called "Thermit." With it you can produce a heat as high as 5,500 degrees F. It is a mixture of granulated aluminum and iron oxide. If you light a fuse, one of those matches that won't blow out, and throw it into this mixture you will be able to make welds and make steel casting on a small scale. You may have seen this "Thermit" used in welding the rails of the electric street car tracks. One of my friends wanted to make a weld on a tug boat's engine with "Thermit," but he did not know, or remember, how hot it was, so when the "Thermit" ran over the clay packed about the broken part it burnt a hole through the bottom of his tug and sunk her. Here is just where book knowledge would have come in.

It is well to memorize the temperatures I give for the melting point of

Wax	150	Deg. F.
Sulphur	240	"
Solder	370	"
Tin	445	"
Lead	620	"
Babbitt	850	"
Copper	2,000	"
Cast Iron	2,000	"
Steel	2,500	"
The freezing point of		
Water is	32	"
Mercury	—40	"
Alcohol	—202	"

When you see the red begin to come in heating a steel rod you will have reached a temperature of about 600 degrees F.; when it gets to a white heat, which sparkles, then you have a temperature of about 2,000 degrees F. Of course, much depends on a man's eyesight and how much light there is in the room, in a test like this.

If you melt babbitt and it seems to take more heat than 850 degrees it may be that the mixture is not the real babbitt—and, to tell the truth, just what babbitt is is hard to say; a good deal depends on what you want to pay for it, and you get just what you pay for. One way to make babbitt is to mix 50 parts of tin, and 1 part of copper, and 5 parts of antimony, or you can use 2 parts tin and 8 parts of zinc, and this is a very good mixture for slow moving bearings. This shows how much babbitt can vary and still be babbitt.

It is very strange how metals and other substances act when very cold. They do not do what you would expect. Take, for example, water; it would shrink in volume until it reaches 40 degrees. If it goes any lower, it begins to expand until it reaches 32 degrees, when it becomes ice, and floats.

At very low temperatures tin becomes almost like glass, very brittle, but its strength increases about 50 percent.

In the newspapers I notice that a Frenchman by the name of Dussand has discovered a way of making a light without any heat. It will be a great advance if this is a commercial discovery. We have known for some time that at very low temperatures substances will begin to glow just as they do in a fire. To explain the action of "Thermit" it must be remembered that the affinity, as it is called, of oxygen and aluminum for each other is very great; that is, when they meet they will at once combine; and when we make it easy for them to do so by the heat which the fusee gives, an enormous heat is made. Some things have no affinity for each other, as oil and water. Now this liking of one substance for another is the basis of chemistry, but the chemist works in a sort of left-handed way. If he thinks a substance is made up of two others, and he wants to prove what one of them is, he guesses what the combination is and mixes with it something which he knows has a great affinity for what he doesn't want, leaving what he wants or supposed was there, and he then makes tests to see if he has guessed right. I don't want it understood that chemistry is not an exact science, for it is; but many times what the chemist gets from his experiments can not be seen, so he has to make some test which will show what it is. To put it in another way: Suppose you had a tank of water and something had been thrown into it, and you wanted to know what it was; you know that heat will evaporate water, so you would heat up the tank and evaporate all the water. What you found in the bottom might look like coal, but it also might look like sand, or some other substance. A chemist would put some of the stuff left in the tank into a glass bottle, or, as it is called, retort, and heat it; after a little he would put a lighted match to the mouth of the retort. If the stuff was sand there would be "nothing doing," but if it was coal the gas which we know is in coal would light, and we would be sure we did not have sand in the tank, and pretty sure we had coal.

You will remember that heat was used to evaporate the water, and by its use most of the chemical work is done; the water was turned into steam and went off into the air, but the coal did not evaporate until more heat was applied.

In the water used in boilers there is to be found certain matter that is said to be in "suspension"; that is, it is simply floating in the water and is not combined chemically, with the gases which go to make up water, oxygen and hydrogen (there are at times chemical unions of matter in water), the heat of the boiler makes this suspended matter sink to the bottom, or "precipitate," as it is called, and the chemist takes this matter in the bottom of the boiler and analyzes it, and can then tell you what you should use to soften or dissolve it in order to keep your boiler clean.

If you look into the window of a drug store you will see glass bottles filled with colored liquids; they are a recognized sign of the trade. Their use for this purpose came about this way: It was looked upon as quite a difficult matter, in the old days, to make a solution, or mixture of colored fluids, and not have them precipitate, so a chemist would mix up a lot and put them in his windows to show the people that he could "do the trick." Some of the old-time chemists wasted a lot of time in trying to find what they called "a universal solvent," that is, something that would dissolve anything that was put into it, but they never seemed to think how, after they got it, they could find anything to keep it in.

Water is about the nearest to a universal solvent that we have, and heat is the great disintegrator, as by its application we can make almost, if not quite all, things separate into what goes to make them up. When we cannot make an article separate we say we have found an "element." We can do some strange things with heat and pressure. In France, some time ago, by the use of great heat and great pressure diamonds were made—not large ones, to be sure, but real diamonds.

F. ORMER BOY.

Technical Publication

Memorandum of Steam Boilers. By William Buchan. Size, 8¾ by 13 inches. Pages, 37. Figures, 102. London, 1912: Wyman & Sons, Ltd. Price, 1s. 3d.; by post, 1s. 5½d.

The author of this book is one of His Majesty's inspectors of factories, and compiled the book at the request of the chief inspector for the guidance of men in charge of steam boilers. It takes up, first, the causes and prevention of explosions and accidents, treating the subject under the following heads: Deterioration and Corrosion; Ignorance or Neglect of Attendance; Water Hammer Action; Undue Working Pressure; Defective Workmanship or Material. Each type of boiler is then described, and the various dangers attributable to the design are pointed out, and following this the various boiler mountings are described and the dangers due to their use are enumerated; also the dangers peculiar to other appliances in connection with boiler plants are carefully considered. The illustrations of all the valves and boiler mountings are of particular value, as both sectional and exterior views are given together with piping arrangements, showing the actual location of the various appliances and the danger which may attend their use. This seems to be about the only time that this subject has been exhaustively treated in printed form, and it should prove of considerable value to boiler makers.

Personal

GEORGE SMITH, superintendent of the Chattanooga Boiler & Tank Company, Chattanooga, Tenn., has resigned to accept the position of superintendent with the Walsh & Weidner Boiler Company, of Chattanooga, Tenn.

E. J. WALSH, formerly with the Casey-Hedges Boiler Company, Chattanooga, Tenn., has been appointed superintendent of the Chattanooga Boiler & Tank Company.

HENRY MELLON, formerly chief layer-out for the Davis & Farnum Manufacturing Works, at Waltham, Mass., has resigned to take a similar position with the Robb Engineering Company at South Framingham, Mass.

FENTON A. RITCHIE, formerly superintendent of the boiler department of the Ames Iron Works, Oswego, N. Y., has moved to Erie, Pa., to accept the position of superintendent of the Nagle Engine & Boiler Works.

Another Boiler Works

The Standard Iron Works, of Vancouver, B. C., began business on March 15. The works are conveniently located on the water front, with the railroad on one side and a wharf on the other. A general boiler, tank and sheet iron business will be carried on. The shop equipment is of the very latest design, and was installed with the idea of handling a job of any magnitude. The young men behind this enterprise are thoroughly equipped, mentally, physically and financially, and we predict a bright future for them if energy and square dealing can be called factors to the road to success.

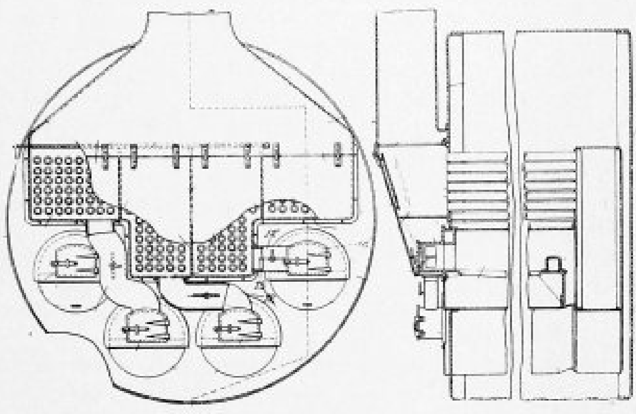
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,008,554. STEAM BOILER. WILLIAM H. MEARS, OF SEATTLE, WASH., ASSIGNOR OF ONE-HALF TO SAMUEL H. MARTIN, OF SEATTLE, WASH.

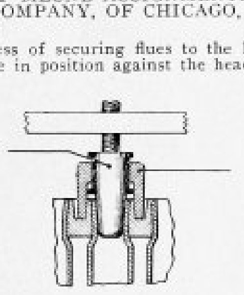
Claim 1.—In combination with a boiler having a plurality of furnaces each provided with a series of tubes for conducting the products of combustion therefrom through one end of the boiler, a casing secured to the last-named end of said boiler over the adjacent ends of the series of tubes thereof, a plurality of vertical partitions in said casing dividing the lower portion thereof into a series of chambers each in-



closing the tubes of a respective series, the upper end portions of said partitions being spaced from the upper wall of said casing, that portion of said casing above said chambers forming an uptake flue, a plate supported for movement in said casing constituting a damper and forming top walls of all but one of said chambers, and extensions from said last-named chambers forming flues each connected with a respective adjoining furnace. Two claims.

1,008,628. BOILER CONSTRUCTION AND MEANS FOR MAKING THE SAME. CHARLES A. BROWN, OF HINSDALE, ILL., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE STEAM POWER DEVICES COMPANY, OF CHICAGO, ILL., A CORPORATION OF ILLINOIS.

Claim 1.—The process of securing flues to the head of a boiler, consisting in placing a flue in position against the head, completing an elec-



tric circuit through the flue and head to weld the same together and exerting lateral pressure upon the flue. Twelve claims.

1,009,275. VERTICAL BOILER. WILLIAM PARIS BARCLAY, OF CHICAGO, ILL.

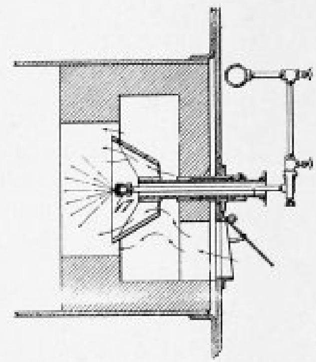
Claim 1.—In a steam boiler the combination of a lower drum, an intermediate conical drum with watertubes connecting the said drums, an annular flange at the upper end of the conical drum, and a superheater drum provided in its lower head with an annular flange fitting with the annular flange on the intermediate conical drum. Four claims.

1,009,217. FURNACE DEVICE. JOHN E. BLAKE AND HENRY H. BLAKE, OF PITTSBURG, PA., ASSIGNORS TO BLAKE CRUSHER & PULVERIZER COMPANY, OF PITTSBURG, PA., A CORPORATION OF PENNSYLVANIA.

Claim 1.—In furnace construction, a plate securable to the exterior wall of a furnace combustion chamber, and having a port adapted to communicate with the combustion chamber, a door carried by said plate, and having a front wall, side walls, an open top and a closed bottom, and disposed in front of said port, and a port-closing and air-inlet controlling member reciprocable vertically between said door and said plate and spaced from said side walls of the door, leaving an air-passage on each side of said member between it and the adjacent side wall of said door, said member in its lowermost positon entirely closing passage through said port. Five claims.

1,009,723. AIR-REGULATING DEVICE FOR OIL-BURNING FURNACES. KNUT M. DAHL, OF SAN FRANCISCO, CAL., ASSIGNOR TO UNION IRON WORKS COMPANY, OF SAN FRANCISCO, CAL., A CORPORATION OF CALIFORNIA.

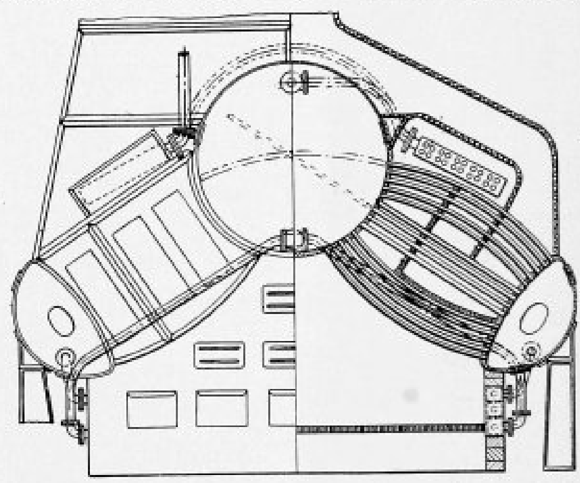
Claim 1.—In a device of the character stated, a furnace having a mixing chamber and an air chamber in rear thereof of greater diameter, a fuel atomizer discharging into the mixing chamber, means for feeding



fuel to said atomizer, a hollow cone-shaped damper having its end of greater diameter presented to said mixing chamber and its rear end communicating with the air chamber, the rear end of said damper being capable of movement in rear of the discharge end of the atomizer, means for feeding air to said chamber and means for adjusting said damper relatively to said atomizer. Ten claims.

1,010,306. BOILER. FREDERICK P. PALEN AND WILLIAM BURLINGHAM, OF NEWPORT NEWS, VA.

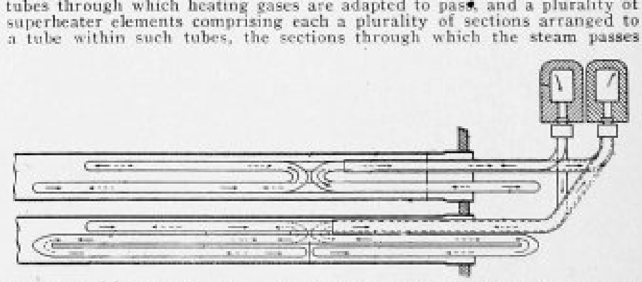
Claim 1.—In a boiler, the combination of the furnace, the water drums, the steam drum, the nests of pipes connecting the water and steam drums, the baffling plates adjacent the nests of pipes, the metal



chambers in the walls of the furnace parallel to and below the lower drums, and the pipes leading from each end of the metal chambers to the water and steam drums. Two claims.

1,010,962. TUBULAR SUPERHEATER. WILHELM SCHMIDT, OF WILHELMSHÖHE, NEAR CASSEL, GERMANY.

Claim 5.—The combination of a boiler structure provided with heating tubes through which heating gases are adapted to pass, and a plurality of superheater elements comprising each a plurality of sections arranged to a tube within such tubes, the sections through which the steam passes



first comprising two connected portions through which the steam travels in opposite directions, and being located adjacent to the outlet of said structure, while the next section of the superheater extends in a portion farther away from the outlet and therefore exposed to greater heat. Five claims.

1,011,213. SUPPLY SYSTEM FOR BOILERS. HERMANN LEMP, OF LYNN, MASS., ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

Claim 1.—The combination of a pump piston and cylinder, a motor having a variable length of stroke for setting the piston in position for its working stroke, and a second motor for imparting a variable working stroke to the piston of the pump. Thirty-seven claims.

THE BOILER MAKER

MAY, 1912

Locomotive Boiler Washing

BY C. E. LESTER *

In the operating department of a railroad company no duty is trivial. The meanest laborer's duties are as essential as those of the management. Every man employed has a duty to perform. If it is necessary that this work be done it is important; if not necessary, the position should be vacated. There are duties, however, more important than others. There is work that may be laxly done that will not reflect greatly on the workman, and that will do no particular harm if not properly completed.

Boiler washing, however, appears to the writer to be one of the very important duties connected with the successful conduction of transportation and maintenance of equipment. It is an operation that should receive the careful attention of the master mechanic and all his subordinates that have in any way anything to do with the subject. It is an operation that is required to be performed conscientiously and thoroughly to give desired results.

There are, of course, localities where the water is so free from mineral salts and organic matter that frequent boiler washing is unnecessary, but the Federal authorities, as well as several State Railroad Commissions, have recognized the fact that no locomotive boiler should remain in service longer than thirty days without washing, and have incorporated this requirement into their rules and regulations for Federal and State supervision of locomotive boilers. This I believe to be a good requirement, only that the term "boiler washing" is too ambiguous, and should be defined and made to mean all that the words imply.

The different kinds of feed water found throughout the country may be defined as alkaline, neutral and acid, though

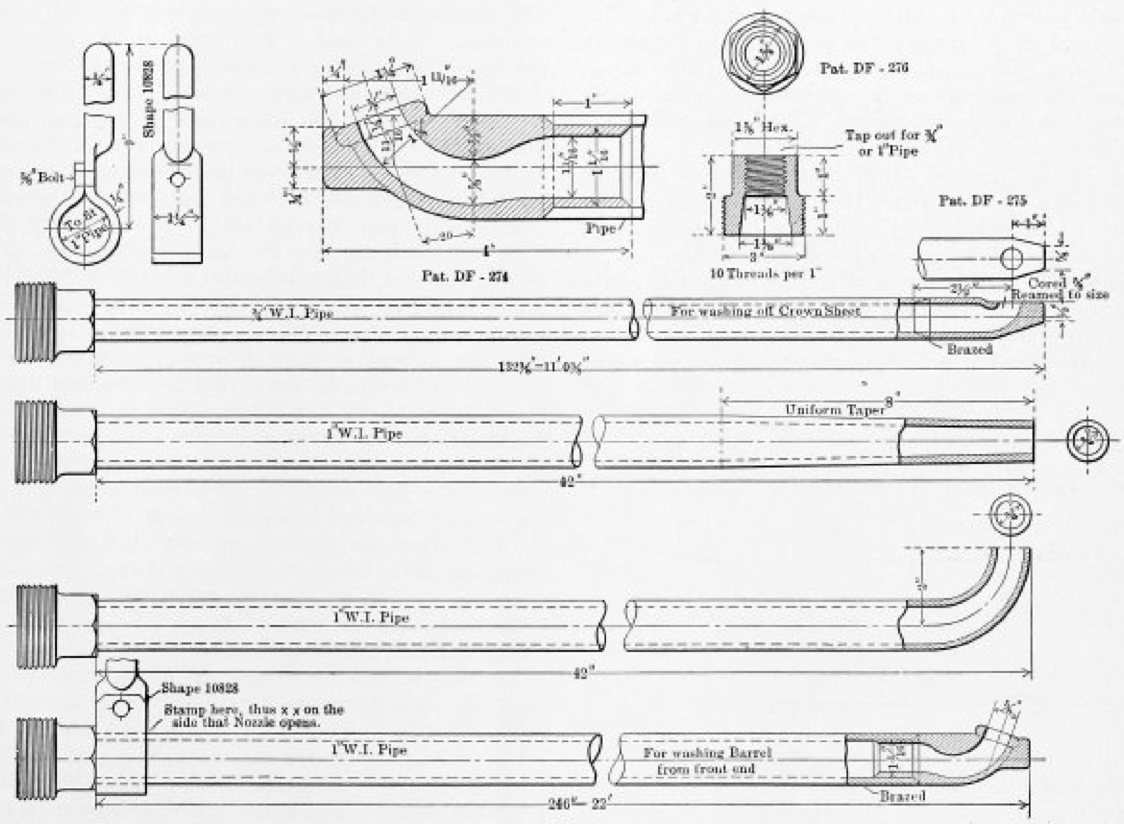


FIG. 1

* Assistant master mechanic. Baltimore & Ohio Railroad, Pittsburg, Pa.

most water is found to be alkaline, with the exception of water in the vicinity of coal mines, in which case acid is frequently found.

Solids found in waters are incrusting and non-incrusting: Sodium sulphate (Na_2SO_4), sodium carbonate (Na_2Co_3), sodium chloride ($NaCl_2$), and sodium nitrate ($NaNo_3$), do not corrode or form scale, but do cause foaming when present in large quantities.

Carbonate of lime ($CaCo_3$) and magnesium carbonate ($MgCo_3$) behave in about the same manner. The bicarbonates when taken into the boiler are decomposed by the heat. The carbonic acid is driven off with the steam, and normal carbonates are formed when the temperature reaches 300 degrees F.

Magnesium carbonate ($MgCo_3$) is the base of boiler lagging, being a non-conductor of heat. It does not take a great stretch of imagination to think what effect a ⅛-inch scale has on the steaming qualities of a boiler.

Sulphate of lime ($CaSo_4$) forms the hardest kind of boiler scale. Precipitation takes place at about 50 pounds pressure on the boilers, at which time heavy crystals of the sulphate attach themselves to the boiler, forming a rock-like scale.

Throughout the Middle States, in a large number of localities, water is found that will run 30 grains in incrusting solids to the United States gallon. This means 4 pounds 4 ounces of solids entering a boiler with every 1,000 gallons of water, or about 34 pounds of solids every time a tank of 8,000 gallons of water is taken.

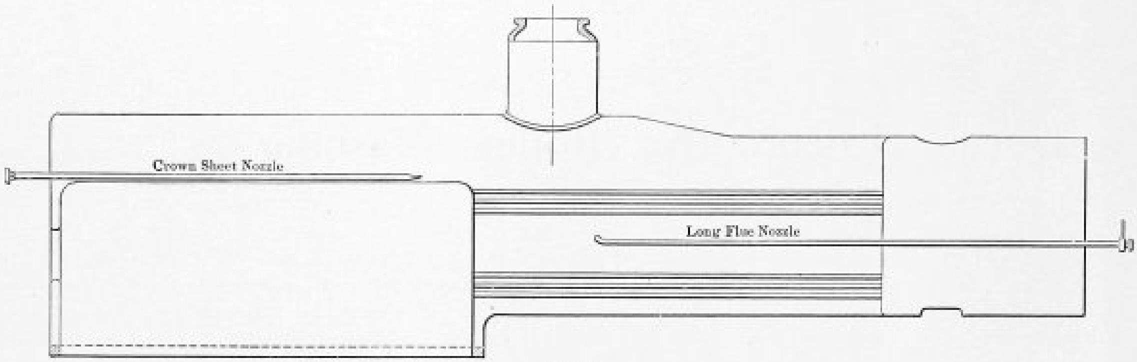


FIG. 2

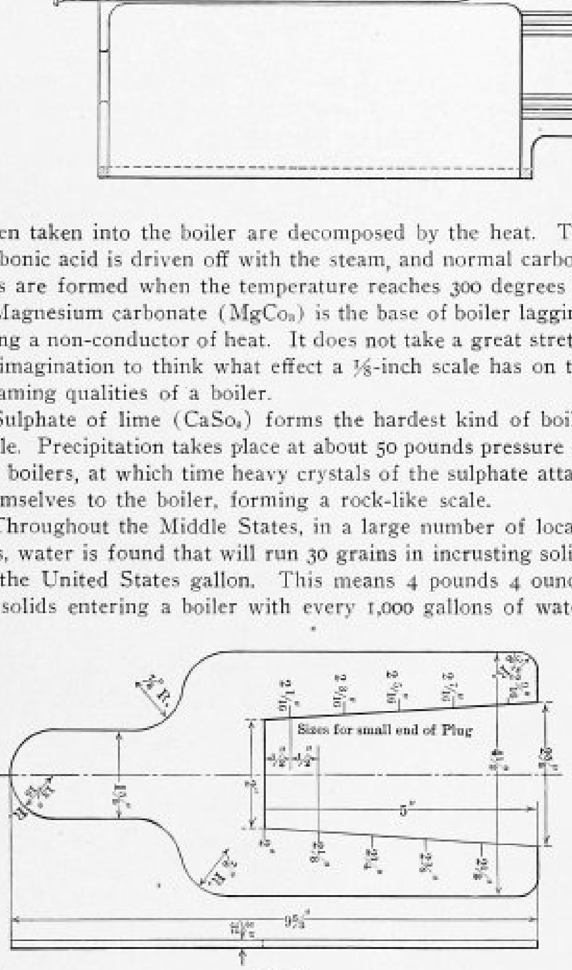


FIG. 3

On a division of 100 miles in heavy freight service water is taken about every 25 miles, hence each way over the division every boiler has injected into it about 136 pounds of solids. On an engine making 50,000 miles between shoppings the total amount of solids would be 34 tons, or about 755 cubic feet. It appears that thorough boiler washing would be somewhat of a necessity in such localities.

It has been stated by competent authorities that a layer of scale ⅛ inch thick requires 20 percent more fuel for a given amount of heat, and that 1 inch of scale offers the same resistance to heat that 10 inches of boiler plate would.

There are on the market various devices, such as water softening plants, boiler compounds and blowing-off devices, many of them very meritorious.

The subject of best methods of treating feed water has been a topic of great interest to master mechanics throughout this country, and was discussed at considerable length at their convention. The use of barium hydrate was brought out in a paper by a committee on the treatment of feed water. There seems to be no doubt but that this reagent is excellent in treating water heavy in sulphates without causing foaming. The principal objection to its use seems to be its cost, the cost being considerably greater than soda ash and a greater quantity required to be used, and that it is extremely poisonous and could not be used in locomotive tender cisterns without the danger of poisoning the engine crews and others.

The fact remains evident, however, that whatever scale solvent may be used the boiler must be frequently cleaned of the fragments of loose scale deposited where heat action could do considerable damage. The blow-off cock is very useful in removing considerable mud and scale by opening every few hours while boilers are in service.

In bad-water districts the boiler washing period can be lengthened by a judicious use of the blow-off cock. When incoming engines arrive at the dump track they should have about one gage of water blown out, and when standing on the out-going track preparatory to leaving time about one gage of water should be blown out; these two blowings out will remove a considerable amount of sludge that has gathered in the boiler legs. In this connection it must be remembered by local officers in charge that unless blow-off cocks are equipped with handles easy of access and in good working order, that the blow-off cock will seldom be opened.

There are boiler troubles of endless variety that may be attributed chiefly to water conditions. Among the most prominent are leaky flues, collapsed flues, leaky stay-bolts, crown bolts, radial stay and seams, cracked side sheets, mud-burned sheets and poor steaming engines.

All these defects may be charged in many cases directly to mud and scale formation, brought about by careless and inefficient boiler washing. All the defects mentioned except poor steaming engines are nearly always caused by overheated sheets caused by scale accumulation, and a great many poor steaming engines have not a thing wrong with them, only such a heavy coating of scale on the heating surfaces that radiation is very poor.

The mechanical department of railroads have as a whole become fully cognizant of the trouble and expense that bad water causes, and have by water treatment and progressive methods of boiler washing attempted to counteract it. In engine houses so equipped hot water is used for washing and filling up.

The system following appears to the writer to be an exceptional good one to follow and unusually good results have been obtained from following it closely. The hot-water system is simply a steam line and a water line joined together with a "Y" connection at the bottom of the drops from the lines on the posts between every other pit, the steam for heating being furnished by the round-house power plant.

WASH-OUT REGULATIONS FOR LOCOMOTIVE BOILERS

(*a*) Locomotive boilers are required to be washed as often as may be necessary to keep them clean and free from scale and sediment.

(*b*) The periods of time between wash-outs on the various divisions are to be governed by the character of the water in use on each division and the mileage made by the engine; provided that the use of a boiler for a longer period than thirty days without washing is forbidden.

(*c*) After the steam pressure has been relieved until no pressure is shown by the gage, the two highest wash-out plugs in the back boiler head are to be removed. Into one of these insert the long nozzle for washing crown sheet and turn water on slowly.

(*d*) As soon as the water is flowing into the boiler under full head, all wash-out plugs, including the plugs in the front tube sheet, are to be loosened so they can be removed by hand, but the complete removal at this stage of the work is forbidden.

(*e*) Removing the plugs or opening the blow-off cocks is forbidden until the water coming from the boiler through the wash-out holes in the back head has been cooled to a temperature of about 125 degrees F., which is, under average conditions, the highest temperature at which the hand can be held in water without discomfort.

(*f*) When the boiler has been cooled to the temperature stated above the blow-off cock is to be opened and all wash-out plugs removed. When this is done begin the work of cleaning the crown sheet with the nozzle which will be already in place, as required in paragraph (*c*).

(*g*) The object of this method is to cool the sheets and tubes while still covered with water, to prevent scale and mud-baking on the hot metal.

(*h*) The nozzle for washing crown sheet is required to be made to conform strictly to Pattern DF No. 275, Fig. 1.

(*i*) After the crown sheet has been thoroughly cleaned, the long nozzle, Pattern DF No. 274, Fig. 1, is required to be used in the top wash-out holes in front flue sheet, delivering a stream of water upward among the flues as the nozzle is moved in and out, turning from side to side until all scale and mud is washed down into the bottom of boiler.

(*j*) All nozzles used through front flue sheet are required to be long enough to reach to back flue sheet.

(*k*) The back flue sheet is required to be washed in the same manner by turning the long nozzle while it is held against the sheet, Fig. 2.

(*l*) The barrel of the boiler is then required to be washed by using the long nozzle in the lower holes in the front flue sheet, driving all scale and mud back into the front water leg.

(*m*) The short and bent nozzles are used next, over the fire-door hole, over the boiler checks and in the side water legs.

(*n*) The last nozzle to be used is the short, straight one; with this the mud-ring is to be thoroughly cleaned from each corner.

(*o*) The scale, wherever it can be reached, is required to be removed, particular attention being paid to crown sheets, side sheets or water leg, over boiler checks, and front water leg at lower tubes. Suitable rods and scrapers are required to be used for this purpose.

(*p*) The ends of rods and scrapers are required to be kept in good order so that they will break the scale.

(*q*) After the washing is completed the boiler inspector is required to make a thorough examination and satisfy himself that all parts are properly cleaned, and it is forbidden to return any boiler to service until it is so cleaned.

(*r*) Before replacing plugs the threads in all holes and on plugs are to be carefully examined to see that they are in good condition, and each plug is required to be put back into its own place. Plugs must conform to standard plug gage, Fig. 3.

(*s*) A mixture of graphite and valve oil is required to be used on all plugs at the time they are replaced.

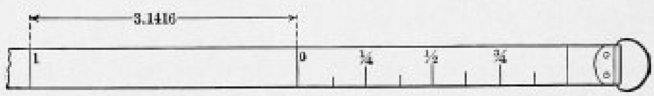
(*t*) Each locomotive is required to be provided with a tin plate which is to be attached to the smoke-arch front, and it is required to be stamped with the symbol of the station and date it was last washed.

(*u*) All boiler washings are required to be promptly reported to the general office on a standard form, and particular attention is required to be given at all times to the instructions printed thereon.

The Layer-Out's Tape

I notice considerable comment of late on making the proper allowance of metal in laying out work. This seems to be a mystery to the apprentice who is learning laying-out. There is, however, on the market a steel tape whereby there is no figuring required on laying out any cylindrical form of work. This tape is divided into what is termed diameter inches on one side and common inches on the other.

The diameter inches are equal to 3.1416 (see sketch tape), and are numbered consecutively up to 1 foot, then they repeat themselves. You will notice on the right-hand side of zero there is also a 1-inch space divided into ½, ¼, ⅛, and these are sub-divided into 64ths, so that one 64th equals the circumference of 1/64 diameter; also the ½ and ¼ equal the circumferences of ½ and ¼ diameters. It should be apparent now that if we had a steel stack to lay out, with tapered courses, say 60 inches diameter ⅜-inch steel, the layout of the large end would be 60⅜ diameter inches, for the small end we



SKETCH OF TAPE

would simply deduct the thickness of the metal from 60 inches, which would give us 59⅝. This in diameter inches would be the layout of the small end, so it is obvious that with the use of one of these tapes all that is required is addition and subtraction; no matter what the thickness of steel, you always have the layout at hand.

Then, again, if you want to know the diameter of some piece of work that is rolled up that you cannot very well measure across, simply run the tape around, and it will give the diameter to a 64th. Now, assume you want the circumference of an even diameter. There is a slide attached whereby sliding it along to, say, 25, which would be 2 feet 1 inch on the diameter side, and turning it over, it would read the circumference.

You may also find the area of a circle on the same tape. One of the rules is to square the diameter and multiply by the constant .7854. Another is to square the radius and multiply by the constant 3.1416. Assume we want to find the area of a 10-inch circle, then the square of the radius, which is 5, would be 25. Move the slide to 25 on the diameter side, turn it over, and the circumference expressed in square inches would be the area of a 10-inch circle. I have tried to get this tape divided into ¼, ⅛, 1/16 the whole length, but the manufacturers tell me the cost would be so great that unless I could guarantee them a large order it would be absurd.

I hope after layer-outs read this article they will see the advantage of using a steel tape, as we would then have everything standard. FRANK SAXE.

Providence, R. I.

The Use of Compressed Air in Boiler Shops*

BY THOMAS ALDCORN

A boiler shop without air tools for one purpose or another is almost unthinkable in these days of close competition. At the same time there are many small and some large shops where extensions or improvements could be made, and the purpose of the present paper is to run over, briefly, the production, transmission and use of air and air tools in a manner which, it is hoped, will be of interest and helpful, to some at least.

The character and quantity of output must of necessity influence or govern the machinery equipment of any shop. Now, from this standpoint, let us run over briefly any general boiler shop. Is the output standardized, and the work, mainly duplication in smaller or larger quantities? Is it special, each case almost individual, or does it fall in the much larger class of jobbing; that is, part repair and part manufacturing?

Each class may be further subdivided, but in final analyses certain fundamental features will be found common to all, with a wide range of special methods, apparatus and uses applicable to each class. It should be borne in mind, also, that a discussion of the general subject will depend upon whether it is to cover an existing plant or the planning of a new installation.

However, a logical treatment is to employ the natural subdivisions of production, or the method and machinery of producing and storing compressed air; transmission or the piping and means for conveying air to the points of application, separators or devices for cleaning and drying the air and the final application or use of air through the medium of the standard tools and a large number of special appliances.

There are a variety of ways to compress air, each having some feature or features which may make it best for a certain set of conditions, and equally unsatisfactory under other conditions. Each installation requires careful individual consideration, and it is not best to attempt to make many sweeping general conditions which will apply equally in all cases, so far as air-compressing machinery is concerned.

Further, conditions change as a shop develops, and an equipment which in the beginning was adequate, and no doubt well selected to meet the then existing conditions, becomes inefficient and unsuited, due to gradual extension and additions not contemplated in the beginning. Besides, the wide range of uses to which compressed air lends itself are not at first fully appreciated, and experience may call for the installation of a device or machine at a remote place, or the use of a special appliance calling for a considerable volume of air, any one of which causes will disturb the balance of a once perfect plant.

Pressure and Volume of Air Required

General experience shows that for best all-around work the proper pressure at the point of application is from 90 to 100 pounds, and in some cases even slightly higher; however, "100 pounds at the tool" will meet every requirement of ninety-nine cases out of every hundred.

To give 90 to 100 pounds at the tool will call for a terminal or receiver pressure of from 100 to 110 pounds, depending on the piping or transmission system, to be discussed later. We now have the first production factor—pressure. Next comes the question of volume of air required, and this in turn necessitates a careful study of present and future requirements. What types of tool, the number of each to be operated; the probable number operating at the same time, the average time of operation of each; what special appliances will be installed; is air to be reheated, and what provision is to be made for growth?

Fairly accurate tables are obtainable, giving the air requirements for all standard tools and machines, and data are available from which the total volume of air needed can be readily worked out, or the manufacturer of compressor and tools will be very glad to assist in determining this second factor.

Compressors

Having obtained the volume necessary, the third prime consideration is the power available for operating the compressor. Here, again, special conditions must govern, and it is not possible to lay down any hard-and-fast rule. If steam is at hand, a steam-driven compressor of simple, duplex or compound type, depending on the steam pressure and volume of air generally recommends itself. With low steam pressure, from 75 to 100 pounds, and a required volume not exceeding 800 feet, a single air cylinder finds frequent use. This type is not the most economical from the steam standpoint, but is compact, simple in construction and has many desirable features.

Above 800 feet, and with the same low steam pressures, the duplex type, with the advantage of four power impulses for each revolution, is frequently employed. Either duplex or two-stage air cylinders are used with this type. When the steam pressure is above 100 pounds compound cylinders should generally be employed, and especially if the steam pressure is much above 100.

For the larger sizes, from 1,000 cubic feet up, compound steam cylinders are almost essential and also two-stage air cylinders. Larger units of 2,000 feet and upwards should be of the Corliss type, their greater first cost being soon offset by the considerable saving effected by their low steam consumption. It is also well when the volume of air to be supplied is large to install two units, either having a capacity equal to light working demands or both together having a combined capacity equal to maximum demand and also some reserve for growth.

It is always well to figure on a machine or equipment in excess of immediate demands, and then operate the plant at less than full speed, with a resulting reserve capacity and increased life. In many shops where shafting is running near the location selected for the compressor, and surplus power is available, a belt-driven machine forms the most satisfactory type. This should be arranged with tight and loose pulley if small or a clutch, so that the compressor can be shut down, should occasion arise, without interrupting the operation of the entire plant. For belt driven, except in the smaller sizes, the duplex; that is, two cylinders side by side, driven from one shaft having a pulley at the center, is the most desirable form, as it gives four compressions per revolution, thus producing a more even belt load.

All belt-driven machines of whatever size or type should be securely anchored to a foundation to insure correct alinement and proper resistance to belt pull. In every instance where electricity is available a belt compressor can be driven from a suitable motor. This arrangement is advantageous, in that it permits starting or stopping at will, without the intervention of idle pulleys, clutches or other power-absorbing devices.

Latterly, electric motor-driven compressors are in considerable demand, either geared, or in the case of larger units, with

* A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

motor mounted directly on the compressor shaft. For the smaller sizes an automatic starting controller and pressure regulator can be furnished if desired, and this will maintain practically a constant pressure, shutting down the motor when the desired limit is reached, or starting up where the pressure falls, due to an increased demand for air.

Still another method of driving in larger units is to mount the motor armature or rotor directly on the compressor shaft, an arrangement somewhat like a direct-driven generator outfit. The power is applied directly to the shaft, and all belts, gears and other parts are unnecessary. This arrangement is without doubt the most simple and efficient type of power-driven compressor. However, it is not available except in sizes from 500 feet and above, because mechanical and electrical reasons will not permit the manufacture of slow-speed motors at sufficiently low cost to compare with motors for belt or gear drive. At the same time the simplicity of this type and its high operating economy recommend its use wherever possible, even at a much higher first cost.

Remember that the power generating plant, of which the air compressor is an important element, is really the heart of your establishment, and it is poor economy to skimp on that end, for a day's shut down due to failure of an essential part may cost you much more in money and prestige than the few extra hundred called for in the beginning by the better equipment.

Piping

In piping up the compressor it is well, if possible, to take the inlet air from the shady side of the building or from outside the engine room, where cool air can be obtained, as each 5 degrees F. reduction in initial temperature will effect a saving of 1 percent in the operation of the compressor, or in-take air 25 degrees colder will increase the capacity of the compressor 5 percent. It is also well to make the inlet of good sizes, and as short and direct as possible, to reduce inlet friction to a minimum.

Often, and always if in a dusty or sooty location, it is advisable to put a strainer on the exposed end of the inlet pipe or box. Such a strainer can be made readily by covering one side of a substantial box with wire netting, and putting outside of this one or two layers of muslin, through which the air must be drawn. While a strainer is not essential under ordinary conditions in many cases it is, and in nearly all cases strained air will help avoid lubrication troubles and add to the life of valves, piston and glands.

The compressed air leaves the compressor at a fairly high temperature, averaging about 350 degrees F. As the amount of invisible moisture which can be held in air depends on its temperature, it is evident that all the moisture taken into the compressor is also discharged therefrom, to condense in the receiver or air mains later on. That this needs consideration is evident when it is recalled that a 500-cubic foot compressor will draw in through the in-take pipe $500 \times 60 \times 10 = 300{,}000$ cubic feet of air per day of 10 hours, and on a damp, rainy day this may contain as much as a barrel of water for the day, although the average would be less. For this reason, especially in the larger installations, an efficient after-cooler is most desirable, and actually essential, if the transmission lines are long or exposed to the outdoors.

After-Cooler

An after-cooler is a device arranged to take advantage of the principle mentioned, *i. e.*, air will carry a varying amount of moisture, depending on its temperature, or at a given temperature air will hold only a certain amount of moisture beyond which it becomes saturated and the excess moisture will be precipitated as dew or rain. Hence if we can reduce the temperature of the air *below* that at which it will enter the transmission mains, moisture troubles will be very largely eliminated. Of course, it must be remembered that when the air is actually used or expanded in the exhaust of the pump, engine, drill or other air-driven device, the rapid expansion causes a temperature reduction considerably below what can be obtained in the usual water-cooled after-cooler, and there may be some precipitation from the compressed air at the point of application. Usually, however, the moisture noticed around air tools is on the outside, and is really the accumulation from the surrounding air, like the moisture on the outside of a glass of ice water.

In principle the after-cooler is simply a tank or receiver, of suitable size and shape to contain a nest of closely placed iron or brass tubes, through which cooling water is circulated. The heated compressed air enters the tank, and by means of baffle plates and tubes is forced to split up into thin sheets which wind in and about the cooling tube, and give up to the water a proportion of the heat contained in the air, if such an expression will be permitted. The heat thus absorbed by the water is carried off and the chilling of the air reduces its saturation point to such an extent that most of the moisture is precipitated and collects at the bottom of the tank portion of the after-cooler. The air then passes out in a very much "dryer" condition. While very desirable in larger installations the after-cooler is not necessary, and many installations have been operating for years without an after-cooler.

Receiver

From the compressor the air passes to the receiver, which performs a two-fold function. First, as an equalizer of the pressure to receive the rapid pulsations of the compressor's discharge, and like a spring or the gas-bag on a gas engine, equalizes or smooth out the pulsations, thus insuring a steady flow of air to the transmission lines. Second, to contain a stored supply of compressed air, which helps the compressor over any sudden momentary increased demand for air. However, there is an erroneous idea current with regard to the storage of air, for without the use of an excessively large receiver it is not possible to store more than a few seconds or a minute's supply. A receiver 48 inches diameter and 12 feet long has a contents of about 153 cubic feet; when filled with air at 100 pounds pressure it will hold about 1,200 cubic feet of free air. If the compressors supplying were shut down, the flow through a 1½-inch main would in a few seconds drop the pressure from 100 pounds to a pressure too low for working purposes. It is therefore evident that except under peculiar conditions the storage feature should be ignored, and a compressor installed of sufficient capacity to easily take care of immediate and reasonable future requirements.

The receiver should always, if possible, be set up outside in a shady and cool place, where the heated air from the compressor may have a chance to cool off and precipitate as much moisture as possible. To take care of this a suitable drain should be provided, and used frequently to blow off any accumulated moisture or excess oil if the operator has been careless enough to allow such a thing to happen.

Frequently it is a good plan to install additional receivers at junction points or elsewhere in the transmission system, to equalize the pressure and to take care of any sudden or excessive local demand. These auxiliary receivers also act as separators to remove from the air additional grit and moisture.

Transmission System or Conveying Pipes

The transmission system or pipes conveying the air from the compressor to the various points of usage should receive most careful attention, both in location and in putting up. Lines should be made of ample proportion and figured with due regard to equivalent areas. They should be run as direct as possible with few turns or angles, and it will pay in the end if bends or long-turn fittings are used. Branches and outlets should be near enough to permit of sufficient tools being operated without the use of long hose lines, usually so that a 50-foot hose will overreach another 50-foot hose. Each branch should have a T and two outlets, closed with good, solid globe or gate valves. The practice of using nothing less than 1-inch pipe for branches is to be recommended. Full-weight pipes, substantial fittings, first-grade valves, and care in supporting mains, drops and branches are all essential, for it must be remembered that with air at 100 pounds pressure a 1/16-inch hole will leak the equivalent of a horsepower for each five minutes. Two or three such leaks even in a large plant would be a serious loss.

All piping should be carefully inspected, rapped to break loose inside scale and then blown out. All joints should be made up with lead and screwed up tight, and every precaution taken to make the work permanently air-tight. At suitable points drip tanks or separators should be inserted in the mains, these being provided with drip cocks. Drip cocks should also be placed at all low points. Further, it should be the duty of some one to see that all drips are blown off frequently and properly.

Outlets should all be provided with an approved form of universal quick-acting and locking hose coupling. And the same form should be used through and on all hose for interchangeability.

Only the best grades of hose should be used, wire-wound for the longer or leader hose, and a short length of plain tubing for connecting with the leader. All hose should be cared for. It is expensive and deteriorates rapidly, and it has been shown that many troubles charged against the tool have been due entirely to the use of poor grades of hose, which stripped or scaled inside and clogged the valve or working part of the air tool equipment. The hose should be regarded as part of the tool equipment, and each man to whom hose is issued should be held responsible for its return in good condition.

In every case when getting ready, the valve at the outlet should be opened an instant before connecting the hose. The hose should then be blown out, and then the hose connected to the tool. We now come to the actual uses of compressed air.

Uses of Compressed Air

Aside from the line of standard power-driven machine tools for the boiler shop, such as shears, bending rolls and punches, there are a large number of standard and special air tools fully as important, the principal ones being:

Pneumatic chipping, calking and bending hammers.
Pneumatic long-stroke riveters.
Pneumatic drills.
Pneumatic reamers.
Pneumatic tappers.
Flue expanders.
Flue cutters.
Yoke riveters.
Compression riveters.
Holders-on.
Jam riveters.
Rippers.
Rivet busters.
Pneumatic hoists.
Cranes.
Pneumatic jacks.
Scaling tools.
Stay-bolt rippers.
Tell-tale hole drillers.
Air forges.
Pneumatic painting machines.
Grinders.

Besides these there are many other special appliances devised to meet peculiar conditions existing in each case. Limited time necessitates merely mentioning the names of most of these, and only a short review of the most important of these can be given.

Chipping and Riveting Hammers

First in importance should be mentioned the chipping and riveting hammers. The chipping, calking and bending hammer is used in six or eight different sizes for every character and weight of work, from the thinnest to the heaviest plates. These tools range in weight from 6 to 16 pounds, with strokes from 1 to 5 inches, and these striking at from 840 to 3,200 per minute, with air at 100 pounds pressure, acting on a 1 1/16-inch diameter piston. It would seem that no argument is necessary to prove the advantage of these wonderful labor-saving tools over the old hand methods in the hands of even ordinary unskilled help.

Pneumatic chipping is unquestionably many times more powerful and efficient than hand chipping or calking. Further, on account of there being no necessity to "swing a hammer" it is possible to work in out-of-the-way places and corners where hand chipping could only be done with the greatest difficulty. The varying sizes of these tools make it possible to select a hammer to meet any peculiar set of conditions, and the spring throttle, which is always under the control of the operator, permits an instantaneous adjustment of the blow, from a very light tap to the full power of the hammer, thus enabling intricate chipping to be done quickly. Further, the chipping can be carried very much closer to the finished size than can possibly be done by hand. When it is considered that an ordinary operator can take a 3/8-inch chip off a 1/2-inch plate at the rate of 8 inches per minute, and this is compared with the time and work which would be required to cut the same chip by hand, some slight idea of the advantage of pneumatic chipping can be gained. It is a conservative statement to say that one man with a pneumatic chipping hammer can do from three to five times as much as he could do by hand.

For calking, the pneumatic hammer is ideal. For by selecting the proper weight of hammer or throttling the air pressure so as to limit the force of the blow, the metal can be condensed and calked with an evenness impossible with hand methods, and the depth of the compacting of the metal can be regulated to suit conditions. In addition to the ordinary plate chipping and calking, in most boiler shops there are usually iron or steel castings, all sorts of brackets and supports, stack bases and other parts in and around the boiler or boiler settings, all of which need a certain amount of dressing. There are also many other special uses found for the chipping hammer, depending upon the particular shop and the type of boiler being handled.

The pneumatic riveting hammer of the long-stroke type, weighing from 14 to 21 pounds, depending on the class of work for which intended and having from 840 to 1,080 blows per minute, is a marvelous device, and even in the hands of an inefficient operator does so much more work and does it so much better than could be possibly done by hand, that it is inconceivable that anyone would tolerate hand riveting of any sort. For any given case experience has pretty conclusively demonstrated that the work can be done in from one-fifth to one-third the time it would require to do it by hand work, with a proportionate reduction in cost and the very considerable advantage of having the work done better.

The reason for this is almost self-evident. It is not safe to heat a steel rivet beyond a certain point if its fibrous texture is to be retained and the full strength of the rivet made available. If the rivet is driven by hand it will be seen that, no matter how rapidly the riveters strike, they cannot possibly upset and head the rivet as quickly as it can be done by a machine which strikes a more powerful blow probably ten to twenty times faster than any riveter can possibly strike. On this account the rivet fills the hole and is headed before it is cooled to any great extent, and as it cools and is followed up by the riveter the plates are clamped together tighter than is the case with a hand-driven rivet. Besides, there is less likelihood of the rivet running over and heading up off center. It is impossible to imagine any form of working machine simpler in construction than a riveting hammer, consisting as it does of the barrel, valve box and valve, handle and trigger, and while we sometimes hear complaint as to the cost of repairs, such cost is trifling compared with the results obtained. In fact, we do not believe it an exaggeration to say that any good shop has its capacity doubled or tripled by the introduction of pneumatic chippers, riveters and drills, which will be discussed later.

It is not necessary to occupy space with tabulated results, but statistics are available to show that it is a fact that pneumatic hammers double, triple, and often quadruple, the working capacity of a man or gang, and in addition do the work better than it can be done by hand.

Special Tools

Along with pneumatic hammers come, of course, pneumatic holders-on for backing up the rivets, jam riveters for working in restricted places or in flues and other positions where the ordinary riveter cannot be operated, rippers for cutting up tanks, boilers and other plate work, rivet busters for flogging off the heads of rivets and stay-bolts, for purposes of repair or absolute dismantling of boilers and tanks, and other special devices of kindred sort, many of which are specially made, having been developed in some particular shop.

Pneumatic compression riveters, either portable or stationary, and yoke riveters of varying design, are largely used where the character of work demands this type, and when properly mounted so as to be flexible they constitute a very important addition to any boiler shop equipment. In principle the compression riveter is much the same as the ordinary hydraulic riveter, except that the riveting plunger is advanced by means of a toggle or an arrangement of levers in turn moved by a piston moving in a compressed air cylinder.

Yoke riveters, on the contrary, are simply a heavy riveting hammer mounted on suitable yoke frame instead of being held by hand, the toe of the yoke constituting the holder-on. These also are largely used for certain classes of work.

Pneumatic Drills

Pneumatic drills are made in sizes ranging from the smallest midget type weighing 6 or 7 pounds to the powerful compound gear type having a capacity to drill up to 3 or 4 inches in metal and weighing up to 118 pounds. In principle they consist of a multiple-cylinder, air-actuated engine, driving a crankshaft, which is geared to the drill spindle or socket which takes the drill. On the smaller sizes the spindle speed is as high as 2,600 revolutions per minute, whereas in the larger compound types mentioned the spindle speed is as low as 36 revolutions per minute. The power of these drills varies, of course, with the air pressure, but it is astonishing to see how rapidly they work and what enormous power they have. Their absolute flexibility lends them to all classes of work and for general drilling, reaming, tapping, flue rolling or cutting out flues from old boilers there is nothing which compares with them, and through their use it has been possible to introduce methods of construction in boiler shops which have worked a revolution in the cost of boilers.

More recently ball-bearings have been substituted for the older types of sleeve bearings and modifications in material made which have reduced the weight and increased the power and life of these drills to a great extent.

In connection with railroad locomotive boilers, rules have been formulated which require drilling of tell-tale holes in stay-bolts, and the small-size pneumatic drills are the most desirable tools for this work or for cleaning out these holes as occasion requires.

Scaling tools for removing the scale from the inside of boilers are nothing more than small light pneumatic tools, striking a fairly light blow but having a very high speed, and they can accomplish an enormous amount of work in a most satisfactory manner in a very short time.

Pneumatic Hoists and Cranes

Pneumatic hoists and pneumatic geared cranes are largely used in boiler shops for convenience in handling the various parts entering into the construction of boilers, in the different stages of their construction from machine to machine, and where air is available a considerable saving in labor can be effected through the use of these devices. The pneumatic cylinder hoist being a direct lift type can be furnished in capacities up to 20 tons and for any reasonable lift. Where this type cannot be used the geared hoist is easily mounted on a hook and swung from a jib-crane or may be arranged to travel on the under flanges of an I-beam trolley track. These can be obtained in standard sizes from 1 to 10 tons. They consist of suitable air motor and necessary gearing, together with drum, all contained in a sturdy frame and suspended from hook or trolley wheels, as the case may be. They are a most desirable adjunct to any boiler shop, and with reasonable care have a long life and make a good showing in every way.

Pneumatic jacks also have a useful field, although not so great as some of the other devices mentioned. In principle they consist of a cylinder with a piston and heavy piston rod projecting through the top head of the cylinder; the air being admitted to the bottom, the piston moves upward exactly as in the case of a hydraulic jack. These can be obtained in stock sizes from 1 ton to 20 tons, and prove themselves a very useful tool, either for permanent installation in some fixed place as an adjunct to a permanent machine or mounted on wheels for ready movement.

Pneumatic forges for rivet heating or tool tempering are light and compact, hence readily transferable and can be taken close up to where the work is being done, thus insuring hot rivets without burning. They are simple in construction, durable and very efficient, and eliminate any necessity for pumping or grinding a rivet forge.

Pneumatic grinders of several sorts can be obtained, and these are very desirable for finishing edges of plates, corners or for any other special grinders where it is desirable to take the tool to the work. They consist of a standard form of air motor, practically the same as that used in the pneumatic drills, with a suitable extension shaft for mounting on wheels which are made for either face grinding or edge grinding.

Pneumatic painting, or paint sprayer, may be used to considerable advantage in and around a boiler shop for painting boilers, tubes, etc., before shipment. In the hands of even an inexperienced operator they do rapid, economical and satisfactory work.

This very brief review of a most comprehensive subject is incomplete, but a paper much longer than the present one could be written on any one of the tools mentioned. However, it is hoped that interest has been aroused and that discussion will be provoked which will bring out special uses and devices which have been found helpful in connection with boiler shop practice.

Editor's Note.—In the report of the Boiler Manufacturers' Convention on page 105 of the April number, it is stated in regard to Mr. Aldcorn's paper on "Conpressed Air in Boiler Shops," which is given in full above, that "Small gas or kerosene-driven units can be obtained which are very economical in use and can be run with about a pint of gasoline per horsepower per hour or 1/8 of a pint of kerosene." This should read 1 1/8 instead of 1/8 of a pint of kerosene per horsepower per hour.

Manufacture of Seamless Steel Boiler Tubes*

BY J. JAY DUNN

This paper is confined to the description of the process of manufacturing seamless steel boiler tubes by the method now most generally in use. Brief mention will be made of processes which have at this time, practically speaking, been superseded.

HISTORICAL

Since the time of Watt and Boulton, late in the eighteenth century, the design of steam boilers has been modified, not to say hampered, by the materials available for construction. At that time plates were made of iron by hammering, and were, necessarily, of small size. Tubes, as we understand the term to-day, could not be obtained at all. Trevithick, early in the nineteenth century, was the first to experience, in a marked degree, the limitations placed on this design by available materials, as he was the first to actively advocate the use of higher pressures. It is probable that Watt's antagonism to the use of higher pressures was due to his clear understanding of the numerous forces which were to be controlled. That Trevithick was able to design and build boilers for steam pressures above 100 pounds to the square inch, with the small and poor quality of wrought iron plates available, is remarkable. Without question, the introduction of the locomotive was delayed at least a dozen years through lack of suitable material, *i. e.*, was delayed until small diameter tubes were available.

The locomotive was not entirely successful until Stephenson, in 1829, equipped the boiler of his Rocket with tubes practically 3 inches in diameter. The boilers for previous locomotives had been designed with a single large flue passing through the boiler, with perhaps one example in which this flue was returned to the firing end of the boiler. The failure, or only partial success, of these early locomotives was due to inadequate supply of steam. The boiler of the locomotive Rocket is typical of all locomotive boilers since designed, there having been no radical changes made down to the present day.

The invention of the process of welding sheets into long tubes had an immediate effect on the design of the stationary and marine boilers as well as the locomotive boiler. The introduction of the Bessemer process and improvements in rolling methods made available larger and better sheets for boiler construction. Bessemer sheets were first used for boiler construction about 1862, but it required not less than twenty years to overcome the objections made against the new material. A few years after the period when Bessemer steel plates began to be used in about equal quantities with wrought iron plates, open-hearth plates became available and have practically supplanted all other material for boiler construction. Tubes continued to be made of wrought iron until about twenty years ago, when Bessemer steel began to be used for the purpose. The use of steel for tubes has steadily increased, until at this time considerably more steel is used than iron. Open-hearth steel for tubes was introduced by the seamless process. The effort to produce a more satisfactory tube than could be made either by butt or lap welding early led inventors to turn their attention to the production of a seamless tube, the purpose being to eliminate all uncertain ties of the welding operation. Among these early attempts to produce a seamless tube might be mentioned a method of extrusion similar to that used by makers of lead pipe, and the method of casting a short, thick, walled hollow cylinder, the walls of which were afterward reduced by rolling or hammering. One of the first successful processes consisted in forming hollow cylinders and tubes from disks of steel by successive cupping and drawing operations. This method has been applied to the production of all sizes, and is in use to-day for large diameter, heavy wall material.

The real beginning of the present process of manufacturing seamless steel boiler flues was the discovery of Mannesmann, that when a round bar of heated metal is caused to revolve by frictional contact between two surfaces, so arranged as to apply a pressure on the metal along the diameter of the bar, the ends of which are in contact with the two surfaces, a rupturing of the metal occurs along the axis of the bar which was being revolved, causing, or tending to cause, the production of a hole along the axial line where operated upon. Mannesmann's invention, and those of the inventors who followed him, relate principally to the mechanism required to cause the revolution of the heated round bar with the pressure applied under correct conditions, and, at the same time, to give the round bar a forward movement as well as one of rotation, and so control the flow of the metal as to produce a hollow cylinder which would be or could be worked into a commercial tube. The Mannesmann process being an expansion of the metal, which reverses the condition found in ordinary rolling processes, tended to open up any defect in the nature of a seam which existed in the material being worked. The process required ideally perfect steel, which, of course, could not be obtained. A great deal of attention was devoted to the designing of machinery for producing hollow billets by the Mannesmann process, in such a manner that the stresses on the material during operation would be so controlled as not to enlarge or extend defects existing in the material worked.

In 1895, Mr. R. C. Stiefel invented a piercing machine, the object of which was to pierce metallic blanks and billets in a heated state, without subjecting them to a torsional strain which would materially disturb the longitudinal arrangement of the fibers of the metal. The piercing machine invented by Mr. Stiefel is at this time producing the major portion of the seamless tubes used in the United States.

MODERN METHODS OF MANUFACTURE

For the manufacture of seamless steel boiler tubes, basic open-hearth steel is used. The steel is made especially for the purpose, every precaution being taken in the melting, casting and rolling to insure sound material. The steel used is low in sulphur, phosphorus and carbon, and usually runs more than 99.25 percent metallic iron. The steel is rolled into blooms 5 inches to 7 inches square, sheared and allowed to cool for inspection. Inspection of the blooms is very rigid. The material which is passed has all surface defects removed by chipping, as is the practice in the production of forging billets. The square blooms are reheated and rolled into various sized rounds, the diameter depending on the size tube which they are intended to make, and the rounds are cut to a length required to give the quantity of metal desired in the finished tube.

The rounds are prepared for the piercing operation by drilling a hole in the center of one end 1 inch in diameter and about 1 inch in depth. This centering of the round is for the purpose of starting the piercing mandrel centrally, and also to relieve the work on the point of the piercing mandrel at the beginning of the operation. After centering, the rounds are charged to a continuous heating furnace, where they are heated to a temperature of about 1,225 degrees C.

PIERCING MACHINE

The essential elements of the piercing machine consist of two shafts, which are parallel and lie in the same horizontal

* A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

plane. They are adjustable in the direction of their axes and are held rigidly against longitudinal movement by thrust bearings. These shafts carry disks, beveled on their outer portion and overlapped in such a manner as to form a pass which first converges and then diverges. The disks rotate at the same speed and in the same direction. They are so related, one to the other, that the sum of the radius of one disk to a given point of contact of the disk with the billet and the radius of the other disk to its given point of contact with the billet diametrically opposite to the assumed point of contact of the first disk is constant. This relation results in each successive cross-section of the billet in contact with the disk rotating at the same speed, thus accomplishing the object of the inventor—not to disturb materially the longitudinal arrangement of the fibers.

The piercing mandrel controls the flow of the metal and determines the wall thickness. The piercing mandrel is supported against longitudinal movement by a mandrel bar, which in turn is supported by a thrust bearing. In operation the piercing mandrel supported on the mandrel bar is placed in the correct position relative to the disks. The heated round billet is brought into contact with the disks, which cause it to rotate and at the same time feed forward onto the piercing mandrel, first reducing diameter of the billet, then expanding it as the metal flows over the piercing mandrel on the form of a tube. The feeding of the billet onto the piercing mandrel is accomplished by holding the billet by means of guides in a horizontal plane above or below the horizontal plane containing the axes of the disk shafts.

After the billet has passed entirely over the piercing mandrel the mandrel bar is withdrawn, and the hollow billet is removed from between the piercing disks and transferred to the rolling mill, for the purpose of reducing the wall to its final thickness and removing corrugations left on both inside and outside surfaces of the tube by the piercing operation. The rolling mill consists of an ordinary stand of two-high rolls, the rolls containing grooves of the diameter required by the finished tube.

Rolling Mill

Lying within the grooves of the roll is a rolling mandrel, which is supported against longitudinal movement by a bar, which is in turn supported by the framework connected to the mill housing. The hollow blank from the piercing mill and in the piercing heat is started between the rolls, which draw the pierced billet over the rolling mandrel, reducing the wall to the required thickness.

From the rolling mill the tube, which is now of approximately the finished diameter and of the finished wall thickness, is transferred to the reeling machine. The work of this machine is to eliminate any variation in the wall thickness left by the rolling mill and to smooth up the interior and exterior surfaces, particularly the interior surface, which may have become somewhat scored by the action of the rolling mandrel.

Reeling Machine

In the reeling machine the movement of the tube is identical with its movement in the piercing operation, *i. e.*, the tube is caused to rotate about its axis and at the same time to advance in a longitudinal direction. In the reeling machine, however, the disks of the piercing mill are replaced by rolls whose axes, while in parallel planes, are inclined to each other. The reeling mandrel is supported by a mandrel bar, as in the piercing operation. The piercing and reeling operations are identical, except that whereas in the piercing machine the piercing mandrel was conical, in the reeling machine the mandrel is cylindrical, the rounded end of the mandrel simply facilitating the entry of the mandrel into the interior of the tube. In reeling, the rolls carried by the shaft are brought into contact with the tube with the reeling mandrel in position. The walls of the tube are under pressure between the surface of rolls and reeling mandrel, the movement of the rolls imparting a motion of rotation and translation to the tube, bringing the reeling mandrel into contact with every point in the interior of the tube, producing a uniformly smooth surface of both interior and exterior.

Reeling Machine to Cooling Table

From the reeling machine the tube is delivered to the conveyor of the sizing mill, which brings the tube accurately to diameter. From the sizing mill the tube passes through a cross rolling machine for straightening, and is delivered to the cooling table. On the cooling table the tubes are kept from coming in contact with each other, and are revolved slowly to insure even and gradual cooling.

Inspection

From the cooling table the tubes are handled by crane to the inspection benches, where they receive inspection for surface. All tubes which pass this inspection are conveyed by crane to the cutting-off machines, where tubes are cut to length. From the cutting-off machines the tubes are rolled down to the hydraulic testing machine. In this machine all boiler tubes are subjected to an internal hydraulic pressure of 1,000 pounds per square inch for the purpose of detecting any weakness which may have passed surface inspection.

From the testing machine the tubes pass to the inspectors for gage. After passing inspection for gage they are stenciled and are then ready for shipment.

Cold-Drawn Tubes

When tubes are to be finished cold-drawn, the hot operations are identical with those just described. The diversion in the process starts after the surface inspection as the tubes come from the cooling table. Tubes which are to be cold-drawn, after passing the surface inspection, are taken to the pointing hammers, where the end of the tube is reduced so that it will pass through the drawing die. After pointing the tube is pickled to remove all mill scale; it is then washed to remove all traces of acid, then dipped into a solution of flour and tallow, which coats all surfaces inside and outside and acts as a lubricant in the drawing operation.

The cold-draw bench consists essentially of a framework supporting a driving mechanism that gives travel to a heavy steel chair. A carriage, with arrangement for gripping the pointed end of the tube and for making connection to the moving bench chain, travels on the framework of the machine. The die, of the correct diameter for forming the outside of tube, is supported in a suitable holder. The mandrel, of the correct diameter for forming the inside diameter of the tube, is carried on the end of a long rod, which is adjustable longitudinally and is anchored at the rear of the framework, so that the mandrel and dies are maintained in correct relation.

The tube to be drawn is placed by the workman on the bench with its pointed end extending through the die so that it may be gripped by the carriage. The mandrel is then inserted into the inside of the tube and the carriage connected to the moving chain. The tube is pulled through the die and over the mandrel, reducing its diameter and its wall thickness. This work is done cold. The operation hardens the material, so that annealing is necessary if further cold-drawing operations are to be done on the same tube or to fit it for most purposes for which tubes are used. This annealing operation is conducted in large furnaces designed to give accurate temperature control, the temperature being observed by pyrometers, so that uniform results may be obtained.

In its inception the seamless tube owes its origin principally to the desire to eliminate the uncertainties of the weld which existed in all other classes of tubes. This uncertainty exists to-day in welded tubes, but is not, probably, a matter of grave importance, as modern methods and materials, combined with rigid inspection, insure welds which will resist stresses occurring in boiler tubes, but it is still desirable to elimnate any uncertainty where it can be done without introducing others of greater moment.

The manufacture of seamless steel tubes, as carried on to-day, not only eliminates the weld as a possible sort of weakness, but the operation is so conducted as to leave the material in an ideal physical state. Throughout the hot operations there is a constant breaking down or refining of the grain of the metal, and at no time is this grain size raised by heating operations.

Physical Tests

The influence of the structure of the material in tubes on the physical properties is most markedly shown in impact and vibratory tests, the grain size having only slight influence on the tensile properties. Tensile tests of seamless steel boiler tubes give the following average results:

Hot-finished boiler tubes—

Elastic limit, 40,300 pounds per square inch.
Ultimate strength, 57,400 pounds per square inch.
Elongation in 8 inches, 30.00 percent.
Reduction of area, 50.2 percent.

Cold-drawn boiler tubes—

Elastic limit, 29,300 pounds per square inch.
Ultimate strength, 52,600 pounds per square inch.
Elongation in 8 inches, 34.00 percent.
Reduction of area, 53.5 percent.

The high elastic ratio of the hot-finished boiler tube is characteristic of the material, and is due to the continuous working of the material in the process of manufacture until the temperature has dropped to the critical point. This high elastic ratio is combined with only slightly less ductility than is shown by the cold-drawn tube. The high elastic limit enables the hot-finished seamless tube to stand the large but unknown stress which occurs in boiler tubes due to temperature variation.

The tensile properties of the seamless cold-drawn tube depend almost entirely on the temperature at which it is annealed. It is standard practice to anneal cold-drawn boiler tubes at the lower critical point of the material, in order that all strains due to cold-drawing may be removed with certainty. As a matter of fact, the stresses due to cold-drawing are eliminated at a temperature approximately 100 degrees C. below the lower critical point. This annealing temperature gives physical properties comparable with those of welded steel tubes, and with a much higher elastic limit and greater ductility than can be obtained with iron.

Corrosion

Any consideration of the corrosion-resisting qualities of seamless steel tubes must be comparative, as conditions of service vary so widely. Until there is some argument as to the theory of corrosion, it will be impossible to speak of corrosion in absolute terms. Speaking generally, the steel tube is superseding the iron tube in locomotive boilers, while in marine boilers for the Government the iron tube has been entirely displaced. The largest manufacturers of watertube boilers for stationary service use seamless steel tubes almost exclusively. This indicates, broadly, that the steel tube is a decided improvement.

Rear Admiral John D. Ford, in a paper read before the American Society of Naval Engineers, gives the following results of an elaborate series of corrosion tests:

Average loss in weight per square inch after 64 weeks, compared with iron, as 100.

1. Hot-drawn seamless steel, open-hearth, 93.7.
2. Lap welded Bessemer steel, 94.5.
3. Cold-drawn seamless steel, open-hearth, 101.3.
4. Charcoal iron, 100.

Mr. Ira H. Wooldon, member of the American Society of Mechanical Engineers, from an investigation made by him while in charge of the Testing Laboratory at Columbia University, concludes: "In my judgment, from the evidence collected, there was absolutely no difference in the corrosion of the two classes of pipe [wrought iron and steel]. They appear to be equally susceptible to the attack."

Mr. P. DeC. Ball, of St. Louis, in a paper, "Steel Pipe vs. Wrought Iron Pipe in Refrigerating Work," concludes: "From thirty-three years of personal observation, construction, erecting and operating ice-making and refrigerating machines, absorption and compression types, and using iron pipes for the first fourteen years and iron and steel pipe for the next nineteen years, we are convinced that local conditions only govern the corrosion of pipes in refrigerating and ice-making machines, and that, chemically and mechanically, mild steel pipe meets the requirements of the refrigerating engineer in all respects, and better than any other pipe, for the reason that it is superior in point of finish, strength, strength of seam and uniformity of material."

From all data obtainable the fair-minded conclusion must be that there is no marked difference in the corrodibility of iron and steel.

Figuring the Strength of Boilers by Simple Methods

I have just been reading the article on page 122 of the April issue, "Figuring Strength of Boilers by Simple Methods." While the methods *are* simple, easily remembered, and for all practical purposes are suitable to use, I think that the reference to the strength of the joints may be misleading to those who do not know about the strength of riveted joints and how the strength is calculated. The article states that only 50 percent of the strength of the plate is realized with a single-riveted joint, and but 70 percent in a double-riveted joint. These values are not always true to every case. Sometimes higher percentages are obtained. The percentages given may be safely taken and used as averages, but it should be made clear to all who may read the article that the strength of single- and double-riveted joints in steam boilers are not necessarily always 50 and 70 percent respectively. Of course, when the factor of safety is considered in connection with the calculation as a whole, the difference of a few percent in the strength of the joint would not materially offset the safe working pressure to be allowed; but the fact still remains that for a given pitch and diameter of rivets, tensile and shearing stress, a certain percentage of strength will be obtained, and if any of these conditions be changed, so also will the strength of the joint be changed. This must be understood by all interested in boiler work, even if they desire to use the values of 50 and 70 as a matter of convenience. In educational work we cannot be too careful in our choice and use of words and phrases. CHAS. J. MASON.

Laying Out Spiral Pipe

A few problems of laying out spiral seams have been given in previous issues of THE BOILER MAKER, but very little information has been made public regarding the details of laying out more than a single turn of spiral pipe built of thick material. Those who have tried to do such work have found quite a different problem in laying out spiral pipe with light gage material than where the metal has considerable thickness. This is a problem for expert layer-outs, and we invite all who have had any experience in such work to contribute short descriptions of the way the work should be done.

History of Charcoal Iron and the Manufacture of Charcoal Iron Boiler Tubes*

BY GEORGE THOMAS, 3D

During the last thirty years we have been living in what has been justly termed the "Age of Steel." With the development and perfection of the Bessemer and open-hearth processes has come not only an enormous output of steel for many purposes, but the means that has brought about our wonderful transportation facilities, our urban development; in fact, the complex life of the Twentieth Century civilization.

As bronze is as necessary to-day as in the era antedating the first rude attempts to convert ore into iron, so charcoal iron in increasing amounts for special purposes is required and demanded.

At the present time many metallurgists have sought to define the difference between iron and steel. One classifies steel as having been cast when molten into a malleable mass. Another prefers to base the difference in steel on its freedom from intermingling slag. Perhaps the simplest and most commonly accepted classification is to denote wrought iron as the product of the puddling furnace or the charcoal hearth. The definition of and difference between iron and steel is of peculiar interest to-day, owing to the fact that large quantities of very soft, pure steel are being marketed as ingot iron, which material should not be sold for nor confused with puddled or charcoal iron. It lacks the protective interlacings of cinder, the fibrous structure, and not only melts at a lower temperature than charcoal iron, but is apt to be red-short at a still lower heat.

The earliest iron was made by directing a blast of air on a hearth charged with charcoal and finely powdered ore. This crude hearth was later developed into the Catalan forge, which, although the charge has varied, is practically the same and produces the same grade of iron as the sinking fire of to-day. That the art was highly developed in early times, and that the product has lasting qualities, is evidenced by the famous iron pillar of Delhi, a shaft 16 inches in diameter by 23 feet high, forged about 300 A. D., a perpetual monument to the excellence of charcoal iron.

The practice of sinking ore direct is a slow operation, requiring much charcoal, involving a heavy loss, and demanding an ore with a very high iron content. It is similar to the method by which fifty years ago forge cinder running about 65 percent iron was as a utilization of at that time a waste product sunk into blooms. At the close of the forge at Standish, N. Y., in 1901, the sinking of ore has not been followed in this country.

Passing from the Catalan forge, used primarily for reducing ore, we come to the Lancashire hearth, used in Sweden and the United States for converting pig iron. Here a more oxidizing flame is used, and the purifying is largely effected by a strongly basic ferruginous slag surrounding the molten particles of iron. In sinking gray iron the pig is melted down before a tuyere, and collects in a slag-surrounded ball at the bottom of the hearth. This mass, not being entirely decarburized, is raised above the tuyere and again remelted through charcoal, when it collects into the final lump or loup.

On account of its lower silicon, white iron in the Lancashire hearth can be converted in one operation, but on account, also, of its higher sulphur the product is inferior. To avoid the excessive labor and charcoal costs incident to sinking gray pig, a preliminary operation was employed, viz., the finery or run-out fire. This consisted of a hearth 2 feet by 3 feet by 2 feet deep with four tuyeres, where gray metal was melted in charcoal and the graphitic changed to combined carbon and the silicon greatly lowered. The metal thus formed could be refined in one operation in the Lancashire hearth.

Having, in a superficial way, followed the conversion of ore and then pig in the forge fire, we come to the conversion of wrought and steel scrap in a hearth of the same character. This method of making charcoal iron is to-day used almost exclusively in America, and to a certain extent in Sweden.

A generation ago many charcoal iron blooms were sunk from wrought scrap. Great care was required in sinking the charge that the iron should not be oxidized, but if this was avoided the bloom was found to be much lower in phosphorus and sulphur than the charge through the molten particles having been refined by the basic cinder engendered.

After 1870, through the development of the steel process in this country, very desirable raw material for making charcoal iron was discovered in certain forms of steel scrap. A charge of this material corresponds to the mixture sunk in the Lancashire hearth at the second refining of gray pig iron. There is sufficient carbon to prevent undue oxidization of the iron. There is sufficient manganese to make a manganiferous as well as ferruginous slag, the first of which is needed to reduce the sulphur, the last required to lower the phosphorus in the charge. There is no excess of silicon, which in sinking pig iron often caused inferior charcoal iron, through making a silicious slag, and consequently preventing the eliminating of phosphorus.

In sinking steel scrap, though, the charge may run .4 and higher in carbon, .6 manganese, .06 sulphur, and .12 phosphorus; the bloom will average under, and will rarely very slightly exceed, .03 carbon, .025 manganese, .02 sulphur, .04 phosphorus, and drillings from all parts of the bloom will analyze alike.

The forge fire usually employed to-day is run with a cold blast and one tuyere, and much depends on the skill and training of the foremen. A hot blast saves charcoal and prevents some loss of metal, but usually produces iron of inferior quality. Two tuyeres work faster, and consequently prevent the forgemen giving proper attention to sinking the mixture. The use of good charcoal, of which about 900 pounds is required to make from scrap a bloom ton of 2,464 pounds, is imperative. The sulphur and silica in coke would in the first case sulphurize the iron; in the latter would make a silicious or acid cinder with no dephosphorizing power.

Charcoal from hard wood, such as maple or hickory, requires a stronger blast, and works faster than charcoal from pine or poplar.

Although the production of iron is increasing in England to-day for employment in bridge and other material where steel, through crystallization and corrosion, has given trouble, its main use in America is confined to iron roofing and charcoal iron boiler tubes. For boiler tubes, charcoal iron is eminently suited. It is of a fibrous nature, and will not crystallize under shock or vibration. It is ductile, can be beaded easily and securely and requires little calking. It is pre-eminently weldable. It is non-corrosive and will not pit.

There are many reasons advanced to account for the noncorrodibility of iron. One has it that the intimately mixed network of cinder forms a protective covering; and under acid

* A paper read before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

conditions, cinder being very little affected, this ingredient undoubtedly preserves the life of iron. Another theory ascribes the superiority of iron to its homogeneous nature, purity and low manganese, which prevent electrolysis. Perhaps both are right. At all events the capacity for production and consumption of charcoal iron is increasing from year to year.

The tonnage of charcoal iron blooms made in the United States, principally for the production of boiler tubes, was in 1908, 55,973 gross tons, and in 1910, 73,974 gross tons, or in the latter year a sufficient tonnage to equip, after allowing for the waste incident to manufacture, 10,000 locomotives with charcoal iron boiler tubes.

It takes about three carloads of charcoal to make, say, 50 tons of charcoal iron to-day. The first thing to be noted is the knobbling fire, which consists of four cast iron plates arranged rectangularly, with a tuyere entering upon one side having a blast pressure of about 1½ pounds. After the loup has been lifted above the charcoal it is placed under the hammer and formed into a bloom. A great deal of the cinder is eliminated, and the rough hansel or slag from the outside is knocked off. A great deal of work on the bloom is necessary here. The bloom is then run into a bar. The bloom is given a wash heat, and then run through passes of a three-high stand of rolls into a bar. After that the bars are piled and cut to length to make a pile of proper weight. Here the piles are heated in a draft furnace. The best practice is with the old-fashioned draft furnace. A blast furnace is liable to blow dust in between the bars and make blisters.

The next step is the two-high plate rolls, where at a welding heat the pile is given several lateral passes to secure the proper width and cross-fiber. Then it is rolled lengthwise to the gage desired. By two-high rolls, the fiber being rolled in one direction only, better results are obtained than in three-high.

After cooling, the plate is marked to the proper size and taken to the rotary shears, where the skelp is sheared to width. Then follows the inspection of the skelp, which is one of the most important steps in the process. Any strip that is found defective is not sent to the tube mill.

In the tube mill the strips of skelp are put into the bending furnace, heated to a red heat and drawn out through a door into the scarfing rolls right at the end of the furnace. The strips go through the rolls, which have a bevel at each edge to give the scarf to the skelp. Then they are drawn through dies which form them into cylindrical shapes, with the scarfed edges, of course, overlapping.

Next is the welding furnace, where each bent skelp is inserted and given a welding heat, when it is pushed out of the furnace to the welding rolls, between which there is a ball on the end of a rod, which is placed between the two concave surfaces of the rolls, and the pressure exerted on the bent skelp as it goes through the rolls is sufficient to secure a weld. The tube is given two welding heats, and goes through the welding rolls twice to insure a weld. The tube is then passed through the size-rolls, where the tube receives its perfect cylindrical shape. The tube goes back and forth through these size-rolls and comes out in its final shape, after which it goes to the cross-rolls, where the tube is straightened and the scale is knocked off.

The cross-rolls are two truncated cones, that have to be adjusted very accurately so that the tube will go exactly through the apex of the cones by which it is straightened as it goes through and any scale knocked off. Then the tube goes out into a trough and is transferred to the cooling rack. This cooling table is operated at different speeds, depending upon the different sizes of the tubes so as to secure the proper heat treatment in cooling as the tube goes over the table to the cradle at the back.

Next is the straightening press, where the tube is pushed back and forth and made absolutely straight. This is a supplementary process to the cross-rolls.

Following this comes the first inspection of the tubes, where in case there are any defects the tubes can be thrown out.

Next the tubes are taken to a cold-saw for sawing the ends of the tubes to give them their proper length. Each end of the tube that has been sawed off is crushed under a press. It requires a very careful man to operate this press, so as to detect any imperfect welds and to be sure that he allows no imperfect tubes to go through. The burr from the saw is taken off and the tube is reamed inside and out. When finished it is probably a little lighter gage at the end than in the interior of the tube.

The next process is a second inspection of the tubes. The tubes are gaged at each end, and the surface is closely inspected inside and out. Then all tubes are tested to 500 pounds hydrostatic pressure (in some cases 1,000 pounds) in a proving trough. The tube is placed in this trough and there is a trunnion that runs up against the end, and then water pressure is applied through the block at the end through the tube up to 500 pounds or more if desired. There is a storage room where tubes that prove to be lighter than the gage for which they were run are kept in stock until an order is received calling for a lighter gage, when they are cut to the length of that order and shipped out.

Another thing if interest is the safe-ending furnace and hammer. The practice here is a very good one. The safe-end is one-quarter inch larger in diameter than the flue. It is pushed over the end of the flue, brought to a welding heat, and drawn down under the hammer to the exact diameter of the flue. In pulling the tubes in a testing machine for the tensile strength we find that the safe-ended flue is practically as strong as the body of the flue. A 2-inch flue that would pull 35,000 pounds tensile strength if safe-ended, and the section containing the safe end be pulled, the tensile strength will probably be 32,000 or 33,000 pounds, and the tubes will not break in the weld.

Another test that is made is called the master mechanic test, showing the expansion of the tube. To meet this test tubes must expand to one and one-eighth times their original diameter. This is a 50-ton press that gives the pressure, and the inserted pin is of conical shape. The pin is driven into one end of the tube until the tube has expanded to the required dimension. The flues are also beaded to show that the metal is of ductile character and will bead over the edge of the flue sheet. There is also a physical testing laboratory, equipped with a testing machine and machines for preparing samples, and a chemical laboratory, where all the raw material is analyzed before it goes into the forge fire. A careful analysis is also taken of the tubes before they are shipped.

A Question for Readers to Answer

One of our subscribers asks the following question, which he would be pleased to have our readers discuss thoroughly in future issues: "What are the best methods of applying patches to fireboxes of locomotive boilers carrying 200 pounds steam pressure when the patches are down at the mud ring where the fire is not so severe and on the side sheets where the fire is most severe? Please give the pitch and size of rivets as well as the pitch and size of patch bolts where the sheets are 5/16-inch steel. I find the patches as applied to-day give a great deal of trouble from cracking at the calking edges through rivet holes. It would lead one to believe that the sheets had not been properly brought together. I note one of your subscribers advocates putting a liner of copper between the patch and sheet. Would this not keep the water too far from the patch and have a tendency to crack the same?" "D."

The Importance of the Furnace in Boiler Design

BY CHARLES S. LINCH

What is flame?

It is incandescent gas.

Is this gas thoroughly incandescent throughout its volume?

It is not.

Let us take a candle and light the wick. We see a conical shaped flame, if we can so use the term.

Let us hold over this flame a piece of metal. We note that at the apex of the flame when in juxtaposition with the plate there is a total absence of smoke.

Now why is this? The answer is that the combustion is perfect.

Let us lower the plate slightly and we note a condition of imperfect combustion, which increases as the plate is lowered. We notice that the flame which apexed, has, when the plate is lowered, the resemblance of an inverted cone. Now the question is, at these stages is the gas incandescent? It is not.

Let us assume that we have a cone of flame. The highest temperature is at the apex, and when we go lower down the cone we find the temperature less. If this cone was flame clear all the way through this could not be. Therefore, we have a hollow conical section, the core of which is gas surrounded by a lamina of gas which is incandescent. As this core of gas approaches the apex it is ignited.

Let us look under the average stationary boiler and see conditions. The flame is impinging on the crown sheet, and has the inverted cone condition, the smoke is rolling around and through the tubes to the chimney, and as we go out to look we see the volume of black smoke which is rolling out. To what is this due? The wise one starts to compute, that there is too much air, there is too much this or that, and in the end the smoke is still making its appearance, and with no intention of ceasing.

Let us look at the furnace. We see that the distance from the crown sheet to the grate bars is as per blue print, and must, of course, be correct. The pocketbook says that the grate bars must be 90 inches from the crown sheet, and as it is infallible it is a crime to think for one moment of questioning its dope.

If it is agreed that the apex of the cone considered is the hottest part of the flame, then why not get the hottest point where needed? If after the flame has flattened out temperature is reduced, why should we adopt that distance? In a battery of boilers which were being installed in a large plant, the request was made to increase the height from the lowest point of the crown sheet to the grate bars, so that the distance would be 5 feet. There was at this plant a battery with the cut-and-dried distance, and the smoke was a great nuisance. The owner of the plant did not relish getting away from the rule of distances, and was more willing to lay out good money to warm the atmosphere than he was to deviate from this good old practice.

Well, after a great deal of talk he took up the subject with several consulting engineers, and they advised him by no means to make any change, and that the man who expounded such ideas was crazy. The man was persistent, and offered to bring the boilers down to this fixed distance if his argument was proved unsound by test, permission being granted after the distance was fixed at 4.5 feet by the owner, although the designer wanted 5 feet.

The boilers were set, and after the plant was started the change in conditions was beyond belief to the owner, and he tried in every way to excuse things rather than give in, but the smoke did not pour from the stack with this battery working and the others cut out. After a month running he called at the office, and could not find words adequate to express his surprise and pleasure, and was indeed very sorry that he did not have the extra 6 inches height, wishing it had been 6 feet instead of 4 feet 6 inches. If you opened the furnace doors and looked in, you could see different—yes, far different conditions from what you witnessed in the old furnaces.

If now in a marine boiler we could get a proper distance between the crown sheet and grate bars, we could get far better results. It stands to reason that when a flame is flattened, so to speak, we cannot obtain good combustion or high temperature. If we could get the flame to apex on the crown sheet we would get far different results. I won't state the saving in fuel this plant showed on test, for I do not remember the exact figures. I do know the boilers went above their rating several percent. It seems to me that if designers in general would simply ignore the so-called rules, get out of the rut, and not travel along lines of least resistance, and above all not to follow blindly in the footsteps of another, we would have results, and bring out the reasoning powers of those in charge, and in the end have a line of good, hard thinkers and originators, not copyists.

Some may think that the analogy is rather far-fetched, but I am not writing for the student of the theory of heat. I want to see engineers do some thinking for themselves. I want to see firemen learn from practical application and simple experiments, which will convey to their mind a truth by concrete application. If I were installing a boiler plant I would have my bars at least 6 feet from the crown sheet, basing the dimension on the average thickness of fire for good results—not a fire that is 2 feet or more thick.

While on the subject of fires I recall a test made of a large plant, where every condition was to be carefully noted; in fact, it was to be a complete test in every detail. While the test was to last twelve consecutive hours, the men at the engine indicators and others in different parts of the engine and fireroom were sweating and fuming, there was one cool man, cool in temperature, with cool nerves, and a pipe being leisurely smoked. That man was the fireman; and for eight hours he had the most enjoyable part of the test. This fireman knew his business; he knew how to fire; his fires were a thing of beauty, and he kept the steam pressure constant; in fact, the gage pointer looked as though it was glued. This fireman was employed for the test at $1.00 per hour, and was worth $2.00 per hour. The engineer who designed the plant called the test off after eight hours' duration, expressing himself perfectly satisfied with the boiler's performance. The efficiency went above the guaranteed without any trouble whatsoever. I have heard of firemen on stationary boilers being fine, but this one surpassed any I ever heard of. He could fire boilers with more ease and with less loss of pressure than any I have heard of. He controlled his fire with a master hand, and the results proved what could be done.

In these days the owners of plants ashore and afloat are awakening to the fact that they must have plants where the economy is assured. They have yet, however, to learn the lesson that the human equation must be dealt with. If I had my way I would have firemen trained and taught the necessary knowledge to enable them to fire as it should be done. They should be trained men, and well paid, for when they are they can save the owners many times their wages, and it would be an incentive for them to do so, and their interest would parallel their employers'. These coal passers which are called firemen are dear at any figure, and they are not firemen. The fire-room is where economy should start. Refined methods there mean more perhaps than many think. It has been proved that a fire-room force of intelligent men can show results that are pleasing when they are looked over, and, above all, get away from these old rules and let us have more intelligent designs and arrangements, and we all need to know more of practical results, combined with our theory, and when practice has shown theory out of harmony, select the results from practice, and give us the means whereby we can improve the most important item in a steam plant—namely, the boiler. The boiler can never be made perfect unless the furnace is perfect.

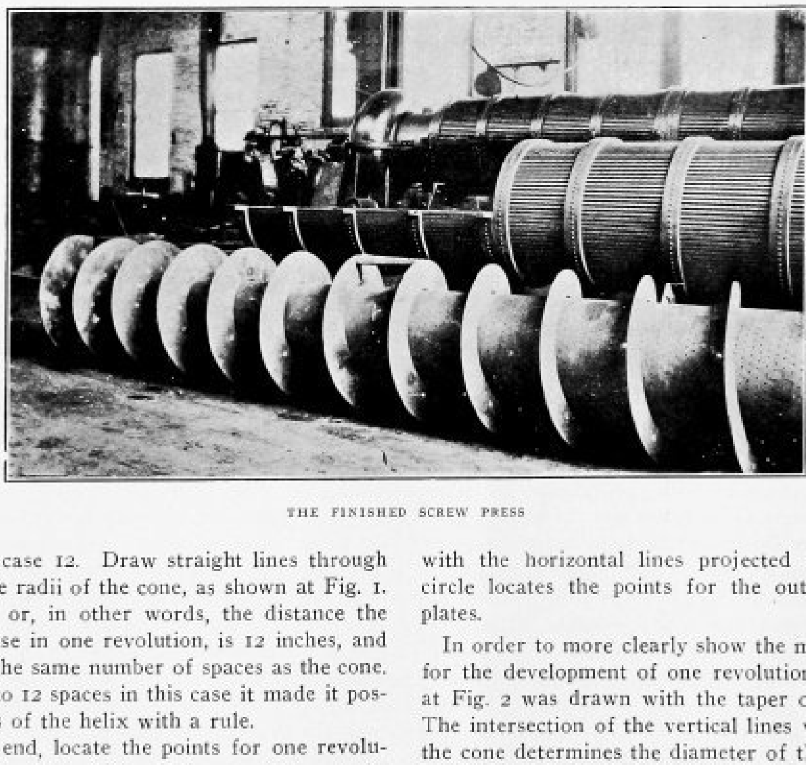
Method of Developing Patterns for a Screw Press

BY PHILLIP A. ROSS*

The following is a description of the method used by the writer to lay out the templets for the object shown in the photograph. While it is an unusual job for a boiler shop it is apt to come up in a shop doing a general line of boiler and plate work.

Recently the Philadelphia Iron Works received an order for several of these screw presses, and the method here described was used by the writer. Material 3/8 inch thick was used for the cone, 5/16 inch thick for the plates forming the spiral, and the angle iron used was 2½ inches by 2½ inches by 5/16 inch.

To lay out the helix around the cone divide both ends of the cone (around the circumference) into the same number of equal spaces, in this case 12. Draw straight lines through these points, forming the radii of the cone, as shown at Fig. 1. The pitch of the helix, or, in other words, the distance the point advances lengthwise in one revolution, is 12 inches, and it must be divided into the same number of spaces as the cone. By dividing the cone into 12 spaces in this case it made it possible to locate the points of the helix with a rule.



THE FINISHED SCREW PRESS

Starting at the small end, locate the points for one revolution; thus, the first point of the helix on line 1 will be at the end, the next point on line 2 will be 1 inch from the end, next point on line 3 will be 2 inches from the end. Point 4, on line 4, will be 3 inches from the end, and so on until all the points for the first revolution are located. Then from points thus located, space off as many 12-inch spaces as the number of revolutions require; draw lines through these points with a flexible steel strip, thus forming the winding curve as shown at Fig. 1. This line was used as a guide for bending the angle-iron, the line for the rivet holes being located at a distance of 1 3/8 inches from the guide line.

To lay out the plates forming the spiral it is necessary to draw a full-size view, as shown at Fig. 1. Draw the cone full size; draw a semi-circle equal to the diameter at each end of the cone, and divide into the same number of equal spaces. Project these points to the ends of the cone, and draw lines connecting the points thus located. Next draw the semi-circle equal to the outside diameter of the spiral, in this case 26 inches. Divide into the same number of equal spaces as the cone and project lengthwise the full length of the cone.

To locate the points for the winding curved line, divide the pitch distance into the same number of equal spaces as the cone, and project points downward, as shown at Fig. 1. The intersection of these lines with the radii of the cone locates points for the winding curve around the cone, or the inside edge of the spiral plates; the intersection of these same lines with the horizontal lines projected from the largest semi-circle locates the points for the outside edge of the spiral plates.

In order to more clearly show the method of locating points for the development of one revolution of the spiral, the view at Fig. 2 was drawn with the taper of the cone exaggerated. The intersection of the vertical lines with the outside edge of the cone determines the diameter of the cone at each point of the curve as it winds around the cone. The diameters thus located are projected to the center line of the plan view at Fig. 3, and are then transferred on the radial lines of the cone in the plan view, as points 1', 2', 3', etc., each point increasing in distance from the center. Lines drawn through these points form the spiral shown at Fig. 3. The outside edge of the spiral is a true circle.

It will be noted that the plan view is foreshortened, and in order to develop the templet at Fig. 4 diagonal dotted lines are drawn, as shown in the plan forming triangles. To lay out the templet at Fig. 4 it will be necessary to get the true length of the dotted lines, the lines forming the inside edge of the spiral, as 1'-2', 2'-3', 3'-4', etc., and the true length of the spaces on the circle, as 1-2, 2-3, etc., Fig. 3. In this case the difference in the length of the various lines was so slight that

* Layer-out Philadelphia Iron Works, Philadelphia, Pa.

to avoid confusion a right angle was drawn, as at Fig. 5, and a point O 1 inch above the base line was located. This represents the distance that the curve advances lengthwise at each space on the cone. Then with dividers set to distance 1'-2', Fig. 3, set one point of the dividers at the center O and the other point resting on the base line; open them until the point resting at O will reach the upper O. This gives the true length of line 1'-2'. The same method was followed to obtain the true lengths of the other lines. The spaces on the outside circle, Fig. 3, are equal, so it is only necessary to get the true length of one space, and it will answer for all.

To lay out the templet, locate points 1'-1 on a straight line equal to distance 1'-1, Fig. 3. From point 1', Fig. 4, and with dividers set to the true length of dotted line 1'-2, Fig. 3, strike an arc; then with dividers set to the true length of space 1-2, Fig. 3, and point 1, Fig. 4, as a center, strike an arc intersecting the arc previously drawn, thus locating point 2. Then

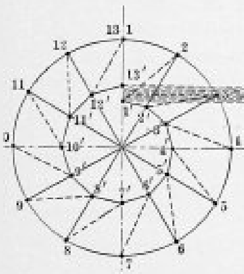


Fig. 3

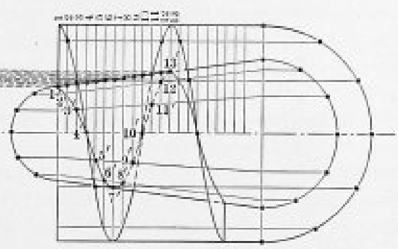


Fig. 2

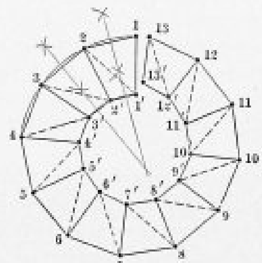


Fig. 4

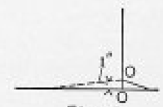


Fig. 5

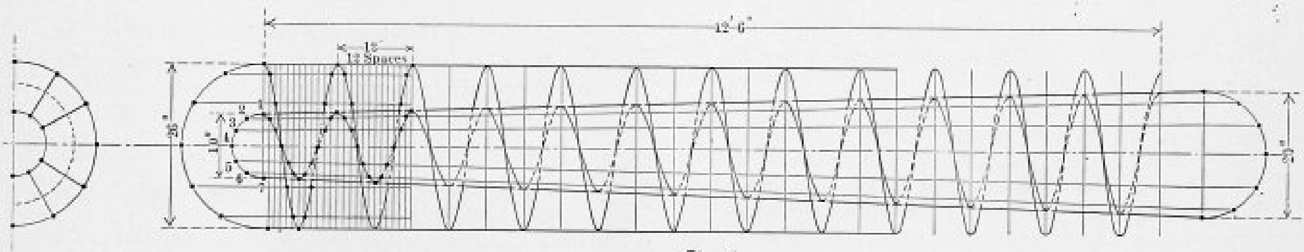


Fig. 1

with dividers set to the true length of line 1'-2', Fig. 3, and point 1', Fig. 4, as a center, strike an arc. Then with dividers set to distance 2'-2, Fig. 3, and point 2, Fig. 4, as a center, strike an arc intersecting the arc previously drawn, locating point 2'.

The rest of the templet is layed out in the same manner. The curved lines through the points thus located may be drawn with a flexible steel strip, or the method may be used for drawing a circle through any three given points. The writer would prefer the latter method.

This completes the templet for one revolution of the spiral. In order to shape the plates to their true form it was necessary to heat them, and as that would very likely cause unequal stretching it was thought advisable to leave the rivet holes out until the plates were formed.

In this case the cones were formed and all joints welded together before the helix was drawn around the cone, but the same principle would apply if the helix was to be located on the flat templet of the cone.

Fatal locomotive boiler explosions occurred on the Southern Pacific, April 4, at Pine Hill, Oregon, killing the engineer and fireman, and on the Western Pacific, April 22, near Winnemucca, Nevada, killing three trainmen.

Generalities Pertaining to Boiler Manufacturing Plants*

BY H. J. HARTLEY †

In undertaking to comply with a request to present another paper before the American Boiler Manufacturers' Association, I am confronted with the difficulty of finding anything entirely new or original in the line of the profession that our name implies, for in these days of general distribution of knowledge of all current events, through the medium of The Boiler Maker and numerous other scientific publications, all matters are made familiar to the public, even in many cases long before actual practice has commenced.

However, speaking from the viewpoint of over forty years' experience in shop management and the various practices in vogue during the interval in the manufacturing of steam boilers and other work in the various branches therewith allied, I presume, fundamentally, to remind those who may contemplate engaging in the manufacturing business, as well as those who are at present engaged therein, that the cardinal principle to success lies in the ability to produce the best quality and the greatest quantity at the least possible cost. This well-established and self-evident proposition cannot be gainsaid or departed from without jeopardizing the success of a business. Therefore, with this object in view, and in order to successfully accomplish the same, an efficient executive organization becomes imperative as an essential in order to make a good start, as there is nothing so conducive to success in any manufacturing establishment as its personnel—from its president down even to the janitor at the door. A certain "esprit de corps" is necessary at all times to insure success, which in turn depends largely on a fitting education of the entirety.

The next important requirement, and which will to a large extent govern the cost in labor on the product, is the having a shop building conveniently located as to transportation facilities, and especially designed, constructed and equipped for the class of work intended to be done therein.

This having been obtained, the next in order is the process of selecting the best and most adaptable and capable modern

* From the proceedings of the American Boiler Manufacturers' Association, 1912.
† Cramp's Shipbuilding Company.

tools, not only fitted for the work to be done at the present time, but for that which may be required in the future, bearing in mind that the limit of larger and heavier construction has not yet been reached, and also that there can be no profitable competition with an inferior plant equipment, which, unfortunately for the owners, is the condition of many existing establishments.

The next essential in this connection consists in properly locating the tools; in fact, it may be termed the most important matter coupled with the whole equipment, and should be carefully studied in every feature before making the start, for if the tools are not placed to the greatest possible advantage an increased cost represented in a useless expenditure of time will be entailed upon the product; consequently an error made in wrongly locating and equipping, even to a small percentage, the details of the outfit of a plant will cause a loss to go on there continuously, thus aggregating what otherwise might have resulted in a fair profit. Moreover, if the mistake of mislocating the equipment of a plant is made it constitutes a false start, and unless too glaring it is likely to so remain, eventually resulting in a loss probably exceeding the original cost—the fact of which may be known only to the foreman or engineer who has made the mistake, neither of whom will care to acknowledge the fault by making the necessary change to remedy the same.

Frequently the before-mentioned mistakes in fitting out boiler and other manufacturing plants are caused by trusting the work to amateur engineers drawn from the office force. instead of to some one who has had experience in the working management of such shops. It matters not, however, who is responsible for the mistake, the loss therefrom continues indefinitely, and in these days of close competition probably causes a loss of contract work to the establishment.

The plant, in case of a new or renovated one, being now in the best possible condition, the successful working management thereafter resolves itself into the question of having a good systematization on the part of those in immediate charge, such as strict discipline and attention to every detail of the business connected with the work in hand, at the same time bearing in mind the cardinal principle of always doing the best and insisting on that rule being strictly carried out through the whole establishment.

The temptation to do a poor job should be, above all other things, strenuously resisted, for by slighting a job the first step is taken toward killing ambition to excel. "A job that is worth doing at all is worth doing well," is an old and true adage, as no botched job goes out of a shop but leaves its trace of demoralization behind; besides, it has cost just as much as if it had been properly done. In this connection the employment of an efficient working force, consisting of both skilled and unskilled labor, becomes a vital consideration as affecting the success of the plant, which will depend upon the skill and ability of the foreman or superintendent in charge to organize the working force and to devise all necessary means for turning out the largest possible quantity of work at the lowest possible cost. In order for him to be able to successfully accomplish this it is necessary for him to have a practical knowledge of the business end of the profession, without which he can never be a successful foreman, even though he be a superior mechanic.

I have frequently seen first-class boiler makers placed in charge of work who ordinarily were capable of performing any and all work pertaining to the business in all its branches, but who had not the slightest idea of economy in the management of their work, such as the length of time it would require to complete a given amount or its probable cost when done. With them it was "any time" so it was eventually done, and at the same time well done. Men of this class, no matter how great their mechanical ability, never make good foremen, and if retained in that position would eventually cause financial ruin to the owners.

Furthermore, in this advanced stage of science in mechanics it becomes necessary for the foreman to be a close student of theoretical as well as of practical methods. He must be able to explain correctly causes of effects, and to know the chemical and physical qualities of the materials with which he has to work. Without such knowledge he will be continually "groping in the dark," with the result that a large percentage of his efforts will prove failures.

Owing to the improved state of all labor-saving machinery and more modern methods in practice, and in order to get the best obtainable results from the capital invested, by an increased output as a minimum cost from the same operating expenses, I would, under conditions where reasonably practical, strongly recommend the piece-work system, in which case the skilled workman will prove the more efficient and valuable.

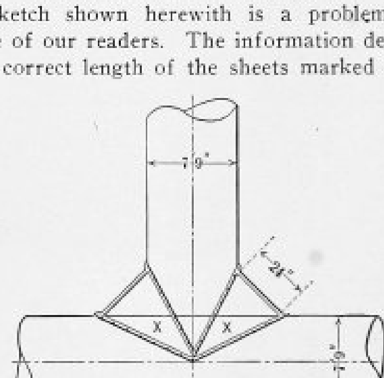
In other words, brains in the present age, instead of brawn as of yore, are the more profitable in modern practice.

In further recommending the piece-work system, I can safely state that from my own experience it has the effect of eliminating to an appreciable extent all labor troubles in regard to wages, strikes, etc., in my locality.

Besides, in all cases where applied it has been the means of increasing the output, with the same operating expenses about 50 percent over and above that of the regular day-work system, and that, too, without the usual necessity on the part of the foreman of watching and driving the workmen, other than to look out for the standard quality of the workmanship being performed.

A Problem for the Layer Outs

In the sketch shown herewith is a problem which has puzzled one of our readers. The information desired is how to find the correct length of the sheets marked *X*. Readers



SKETCH OF CONNECTION BETWEEN INTERSECTING PIPES

are invited to give a complete solution of this problem, showing the layout of the sheets marked *X*. The best solutions of this problem will be published in early issues.

Modern Steam Generators was the subject of an address before the National Association of Stationary Engineers, Pittsburg, Pa., on April 18, by J. R. Mason, representing the Wickes Boiler Company. Several different points in boiler construction were taken up and discussed fully by the speaker, who cited authorities for his claims. The engineers were asked to use their best offices to secure the enactment of uniform boiler laws whereby better construction and workmanship can be secured. The question of gas passages and absorption was given special attention. The speaker read extracts from a paper written by E. C. Fisher on "A Plea for Better Commercial Boiler Efficiency," to illustrate the best arrangements for heating surface and gas passages to obtain the highest every-day efficiency.

Modern Boiler Shops and How Same Should Be Equipped*

BY H. C. MEINHOLTZ

The planning of a better shop involves a most careful study, principally on account of the variety of work that is, or may be, done in a shop fitted with modern appliances. We cannot calculate on building one particular class of boilers, smoke-stacks, etc., but must consider also the general line of tank work, smoke flues, flumes and even structural work that must, of necessity, be done in connection with the regular line of boiler work. Usually a manufacturer has a particular line of work in hand and his principal object is to fit himself with a shop and tools to fabricate such specialties at a minimum cost.

The selection of a proper site for the erection of a shop is very important and, as every boiler manufacturer is expected to attend to repair work besides the building of new work, the ground that may be available often determines the arrangement of building and machinery. In order to take advantage of the profits that may be earned on account of sundry repair work, it is necessary to locate near the manufacturing centers of the large cities, while on the other hand a strictly manufacturing plant may be located on the outskirts or in the suburbs of the city. Experience teaches us that the better and more intelligent class of mechanics favors living in or close to the large cities, principally because they are offered more opportunities to learn what work is accomplished by other men engaged in the same occupation, and they can also provide better and cheaper means for educating and entertaining their families. While it is true that in a community with an established manufacturing plant there should be no scarcity of labor, yet we much admit that at certain times a boiler manufacturer is seriously handicapped for want of work to keep all his men employed advantageously, and at such times a manufacturer located close to the labor market has a decided advantage; he may release part of his labor at times, when necessary, with a certain assurance that he can again obtain the class of labor when such is needed.

A modern boiler shop should be built of fireproof construction. All wood-work should be avoided as much as possible. The walls, columns, girders and roof should be built of non-combustible materials. A maximum of natural light and air should be supplied to the workmen, and the construction should be such that a warm shop in winter and as cool a shop as possible is provided for the summer months. The most serviceable shops are built of brick or concrete walls, with a concrete roof supported on steel trusses, this concrete roof to be reinforced with heavy steel wire and covered with the regulation composition or prepared roofing. The roof is to be built in such a manner that ample ventilation is provided, and the fumes from the open fires and the excess heat caused by such fires during the summer months will pass freely to the open air. Hoods such as are usually placed over the fireplaces and heating forges do not provide ample means for carrying off the products of combustion. Window frames fitted with three sashes in height, in place of two, are desirable; and in such construction two-thirds of the window opening is available for ventilation; a simple window frame is used, and the usual box frame is dispensed with, since the middle sash is fixed or stationary and the upper and lower sashes are fixed to chains that pass over pulleys and are made to balance each other, thus doing away with the customary sash weights.

* A paper read before the American Boiler Manufacturers' Association, March, 1912.

All buildings should be built of ample height, and nowhere should the distance from the bottom of the roof truss to the floor level be less than twenty feet.

When possible, the shop should be planned to have a main erecting floor of suitable width and length, and the crane-way should be built so that a traveling crane may travel the full length of the floor and should be placed at a height so that the operator of the crane may pick up a piece of work at any point and carry same above all other work and the work on the floor need not be disturbed.

Lean-tos should be built on both sides of the erecting floor, and the regular boiler shop machines should be placed in such lean-tos, so as to preserve a clear or unobstructed erecting floor. Lean-tos 40 feet wide are of ample width to place the regulation punches, shears, rolls, etc.

While planning the location of the various machines, the loading and unloading facilities must be considered, since the tonnage of steel passing through a boiler shop is enormous and the least handling or transportation of material is desirable. It is essential that the unloading of raw materials from cars be done at a different point than the loading of the finished product, since in this manner a regular route of travel for the work through the shop can be established. Proper racks should be provided, so that, immediately upon unloading plates from the cars, they can be properly assorted. Racks in which plates are placed in a vertical position are preferable, since less floor space is occupied in this manner. The layer-out should have his place close to the plate racks and the splitting shears should be close at hand for possible cutting of plates. All the punches required should be placed in line, and following these the bevel shears or planers for beveling the edges of the sheets should follow as well as the rolls for rolling sheets. At this stage in the manufacture, fitting-up is done, and space should be provided for reaming machines to ream rivet holes and make ready for the riveter. In a 40-foot bay or lean-to, as referred to, the splitting shears, bevel shears and planers may be set opposite the punches. The roof trusses supporting the roof over the lean-to should be of ample strength to permit of placing runway or rails for small hand cranes underneath same. A double set of cranes are best suited; in place of having such hand cranes 40 feet long, it is better to make the cranes each 20 feet long and arranged so that one set of cranes will pass the other. The advantage of such an arrangement is easily seen, as each machine may have its own crane; nevertheless the operator on any one machine may remove his work and transport same to another machine without interfering with his neighbor, by simply taking hold of his work with the crane on the adjacent runway and passing it along. These cranes can also be provided with interlocking devices so that a continuous crane 40 feet long can be made of the two shorter ones. Owing to the fact that the sharp edges on plate are apt to injure workmen, it is advisable to have a clear floor all around the machines and industrial railway tracks are not desirable about machines where plates are handled. Riveters should be placed in the lean-to, fitted with the customary cranes, so placed that the work from the riveter can easily be reached by the main crane over the erecting floor.

All the plate punches, shears, rolls, etc., should be fitted with independent motors, and all motors should be of the same manufacture and speed. By selecting a few sizes of such motors, making them a standard and by carrying an extra motor of each size on hand, no serious delays can occur, since a spare motor can readily be used to replace a defective machine and no fitting of base plates or change of gearing need be done. Where no extra motors are at hand, often a motor from another machine not in use may be utilized.

Flange shops should be separated from the main shop, wherever possible, but should be located so that the work may be passed from one shop to the other with little expense. Besides the customary flanging machines a large furnace should be provided, so that all flanged work may be heated, straightened and properly annealed.

The power house should be isolated from the main and flange shop, and if possible should be located as far as possible from all open fires, to prevent the fine ash from the fires being carried into the engine-room and deposited on the machines. Besides the engine and air compressor the hydraulic pump and accumulator should be placed in the engine-room, so that all power units may be directly in care of the engine-room attendant. The hydraulic riveters, punches, flanging machines, etc., should be arranged in such a manner that the distance of travel of the water through the pipes supplying the various machines is reduced to a minimum. Proper shock-absorbing valves should be placed, as well as safety appliances to prevent over pumping the accumulator; a special check valve should be placed in the supply pipe to the accumulator, so that in case of a failure in the hydraulic pipe the accumulator will not drop suddenly and injure the machine or buildings. The hydraulic pump should be fitted with a speed-controlling device, so that a fixed speed of the pump cannot be exceeded in case of a break in the pressure line. It has been the custom to equip shops containing machines that are of necessity operated at variable speeds with direct current generator and motors, but for operating a boiler shop we can safely consider alternating-current machines, since the variations of speed that can be obtained with the alternating-current motors are quite ample for all purposes.

A special section of the shop, preferably close to the loading or shipping track, should be set aside for a test floor and a system of drains should connect the floor with a reserve or storage cistern. A cistern of the kind will serve more than one purpose. Besides enabling a manufacturer to save the water used for testing, it also provides a means of storing a few days' supply of rainwater, that may be led to this cistern from all roof area, and in case of any mishap to the regular water supply the necessary water for operating the steam plant may be drawn from such cistern.

While we are considering a strictly fireproof shop, we must, nevertheless, provide the necessary means to successfully fight a fire and an adequate number of non-freezable fire-plugs should be installed with the necessary hose and nozzles attached to such plugs, and care should be exercised in arranging the supply pipe for such fire-plugs; no stop cocks or shut-off valves should be permitted in supply pipes, and the water at full pressure should always be carried to the valve of the fire-plug. While it may seem an unnecessary precaution to nt a shop of this kind with these appliances, yet freight cars of all kinds are switched into the works, and it is well to guard against disastrous fires that may start in one of these cars and ruin the steel structural work on account of the heat that may arise from so large a quantity of wood burning in a small space. Chemical fire extinguishers should also be available.

A separate building should be provided for the storage of oils, paints, etc., and only small quantities of such oils and paints required for immediate use should be permitted in the shop.

In the majority of shops no provision is made for heating in cold weather. It is a mistaken idea to expect workmen to keep themselves warm by work, as there are a great many men employed at work that do not require sufficient amount of action for this purpose, and means should be provided to maintain a shop temperature of about 50 degrees in severe cold weather. A number of indirect heating systems are now on the market that will permit of regulation, so that a shop may be heated and the temperature held at a desirable point.

Programme of the Master Boiler Makers' Convention

The topics to be discussed at the sixth annual convention of the Master Boiler Makers' Association at the Fort Pitt Hotel, Pittsburg, Pa., May 14, 15, 16 and 17, are as follows:

"Best method of applying flues; best method of caring for flues while engines are on the road and at terminals, and best tools for same."

"Steel vs. iron flues. What advantages and what success in welding them, and effect of length of tube and maintenance?"

"Best method of staying the front portion of crown sheet on radial top boilers to prevent cracking of flue sheets in top flange. Cause of flue holes in back-flue sheet elongating and a preventive for same, and effect of the use of combustion chamber."

"What are the advantages and disadvantages of the use of brick arches and arch pipes in locomotive fireboxes?"

"What can be done to produce better circulation in marine return tubular and vertical boilers?"

"What are the advantages and disadvantages of using oxy-acetylene process in making repairs to boilers?"

"Apprenticeship."

"Feed water, etc., and the results obtained."

"When is a locomotive boiler in its weakest condition?"

"Smoke prevention."

"Spark arresters."

"Superheating steam."

Arrangements have been made for an excursion under the auspices of the National Tube Company and the Carnegie Steel Company, on a special train on the Pennsylvania lines to visit works in McKeesport, Homestead and Ellwood City, for the purpose of inspecting the manufacture and fabrication of the various parts of a steam boiler.

Mrs. John McKeown, president of the Women's Auxiliary M. B. M. A., would be pleased to have every lady of the Women's Auxiliary attend this convention. A business meeting will be held on May 16 at 9:30 A. M.

Notice to Tool and Material Manufacturers, Mechanical Engineers and Boiler Buyers

At the Twenty-fourth Annual Convention of the American Boiler Manufacturers' Association the Secretary of the Supplymen's Association was authorized to publish a list of boiler manufacturers in the United States and Canada. This list comprises 1,000 names of boiler manufactureres in the United States and Canada, which have been verified through mercantile agencies and by direct correspondence, making same authentic, and will be of interest to manufacturers of tools used in boiler shops, material men, mechanical engineers and boiler buyers. The book is also arranged with a column in which the credit rating and financial responsibility can be inserted. Price per copy, $5.00,

Apply to F. B. Slocum, Secretary, Supplymen's Association, care of Continental Iron Works, West and Cayler Streets, Brooklyn, N. Y.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

An attractive programme is offered for the annual convention of the Master Boiler Makers' Association this year, and, as the meeting is to be held in Pittsburg, none of the old-timers will fail to come early and stay late, in order to not miss any of the opportunities for getting in close touch with their fellow-workers again, and also to inspect some of the most important American steel industries. Those who have so far had little to do with the active work of this association are urged especially to make it a point to be present this year, because many subjects which have been before the association in recent years are still open for discussion and should be brought up to date. Questions like apprenticeship, smoke prevention, superheating, the value of brick arches and steel and iron tubes are growing more important every year, and much of the success of boiler making depends upon how these various questions are treated in the boiler shop. Exceptional opportunities will also be offered for visiting some of the most important manufacturing plants which furnish material for boiler work, and, besides this, some of the most up-to-date and progressive railway, contract and marine boiler shops in the country are located in Pittsburg, and a little extra time spent in taking observations in such plants will be of immense benefit to master boiler makers.

Furnace design, in both externally and internally-fired boilers, is a question which is frequently neglected by the boiler maker. It is a subject which seems to concern chiefly the engineer and firemen who have charge of the boiler in operation, so that if the boiler itself is in first-class condition when it leaves the boiler shop the boiler maker feels that his connection with the job is at an end. After the boiler leaves the shop, however, it may prove satisfactory to the owner or it may not. If it takes an excessive amount of coal to get the required steam from the boiler it will prove an expensive burden for the owner. Most of the losses in this respect come from the furnace where the fuel is burned. It is, therefore, of first importance to give careful consideration to the arrangement and proportions of the furnace, so that complete combustion of the fuel will be obtained. To thoroughly understand the design of a furnace requires a careful study of the question of combustion and the means available for getting the greatest amount of heat from the fuel into the boiler. An interesting example of this is brought out by one of our contributors this month, who shows how the performance of the boiler is bettered when the distance between the crown sheet of the boiler and the grate bars is made sufficient to give the gases distilled from the fuel a chance to burn completely before being chilled by contact with the surfaces of the boiler. This is one point in connection with furnace design which is of great importance, but there are others of equal importance, and, in order to obtain the best results, each should be carefully considered.

Much of the success of a boiler making establishment depends upon boiler shop management. Elsewhere in this issue will be found some useful suggestions in this respect given in a paper presented at the recent convention of boiler manufacturers by the superintendent of the boiler department of one of the large shipyards. As he is a man with over forty years' experience as a shop manager, his statements are worthy of careful consideration. He points out very clearly that the successful manager must not only be a leader of men and a good mechanic, but he must also have a thorough grasp of the business end of the trade, in order to be able to produce the greatest value at the lowest cost, as well as to have a broad knowledge of the theoretical and practical methods of boiler making. In other words, the successful boiler shop manager must be more than a boss workman, he must have many of the qualifications of a trained engineer.

New Improved Engineering Specialties for Boiler-Making

A New Tube Cleaner

Joseph T. Ryerson & Son, Chicago, Ill., has just introduced a new tube-cleaning attachment specially designed to be used in connection with the Ryerson tube-cutting machine. This combination for tube cleaning and tube cutting gives the boiler maker two complete machines for scarcely more than the price of one, and which requires only the working space of one. More important than this, however, is the character of its work. When cleaning tubes it is claimed that one passage through the cleaning burrs finishes the job, traveling about 10 feet per minute, and that the scale is thoroughly scoured off the tubes without damage due to denting or chipping.

The essential elements of the device are the friction wheel and the adjustable twin roller cleaning burrs, which are built up of hardened serrated steel disks. These twin roller cleaning burrs are assembled in a unit which is readily inter-

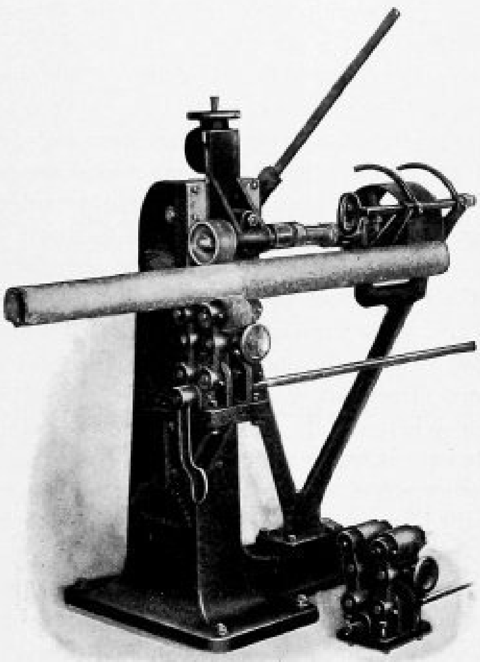


FIG. 1

changeable with the roller tube support employed when the machine is used for cutting tubes. Hence only two changes are required to change the cutting machine over to a cleaning machine: (1) Replace the cutting disk with the friction wheel,, and (2) replace the tube support with the cleaning burrs.

As is the case when the machine is used for cutting tubes, the longitudinal travel of the tubes is effected by adjusting the roller support, which is pivoted, slightly out of square—the direction of travel and the rate of speed being determined by the angles of divergence. Special attention is directed to the intention to furnish these machines complete for both cutting and cleaning unless otherwise specified; but if desired, machines can be furnished equipped with cutter and reamer only.

When equipped for cutting tubes this machine is designed to meet the requirements of the general run of shop work, and handles tubes from 3/8-inch to 6 inches in diameter. The main spindle bearing is turned from the best quality of bronze, and the driving shaft bearing is lined with high-grade Glyco metal. Noiseless running is claimed by the use of a universal shaft for connecting the driving shaft with the main spindle, which does away with all gearing and consequent noise. The cutting disk is 4½ inches in diameter, and is secured on the main spindle, which rotates in the vertical sliding head, and is held in position by the reamer, which serves as a lock nut. The feed of the cutting disk is controlled by means of the counter-balanced hand lever. The convenient position of the taper reamer opposite the cutting disk is an important feature. It is claimed that in five minutes' time this machine and two men

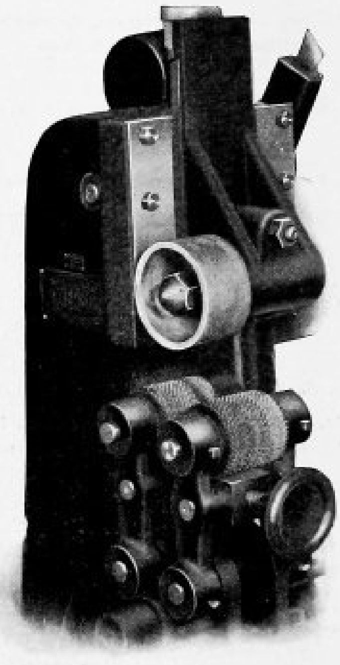


FIG. 2

can do more work and much better work than heretofore in two hours the same two men could do by the former hand method. A three-fold economy is claimed because (1) it reduces the cost of cleaning to less than one-tenth of the hand method; (2) it saves the labor cost of carrying the tubes between machines, and (3) it is the ideal tool for the moderate-sized shop, as the one machine will do all the work which, at best, would otherwise require two separate machines, thereby saving the expense and floor space of a second machine.

A Powerful Jack

The United States Government has recently purchased from the Duff Manufacturing Company, of Pittsburg, Pa., a Duff-Bethlehem hydraulic jack capable of lifting a load of 500 tons. This jack, which is intended for use in the Washington navy yard, is of the independent pump type, consisting of two distinctly separate parts, one containing the water reservoir with its pump chambers and the other the ram or lifting mechanism. Flexible copper tubing, capable of withstanding a pressure of 10,000 pounds per square inch, connects the two parts. This arrangement permits of the ram being placed in any position where there is sufficient room for it to rest, while the pumping mechanism can be placed at a sufficient distance to allow the operator plenty of working room.

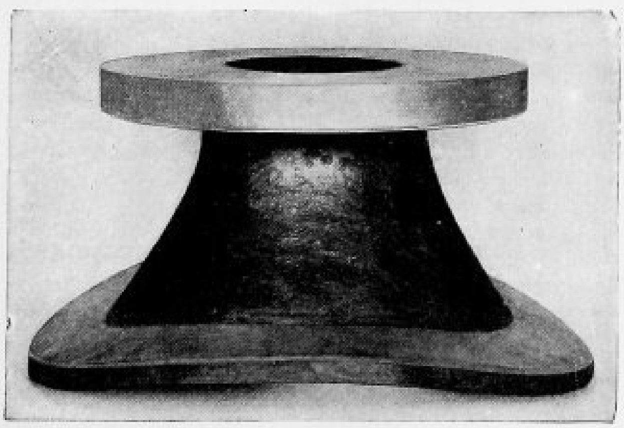
The pump is of the improved Duplex type, providing an accumulative stroke on the upward motion of the pump piston and a working stroke on the downward movement. The pump is so arranged that it is claimed a light load can be lifted five times as fast as a heavy load. This differential speed is automatically spring controlled, and requires no regulation of valves by the operator. The high speed is used for loads up to 35 percent of the capacity of the jack. In lifting loads greater than 35 percent of the total capacity the spring-controlled valve automatically opens at the predetermined pres-

sure per square inch, and the pump becomes single acting, working on the down stroke only.

Another feature of this jack is the gage, which shows the exact lifting pressure that is being exerted. This gage acts as a scale, and registers in tons the weight that is being lifted.

Taylor Seamless Forged Steel Boiler Nozzle

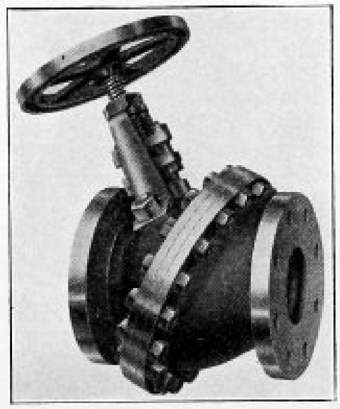
The American Spiral Pipe Works, of Chicago, Ill., manufactures a boiler nozzle which is forged from a single piece of open-hearth steel without a weld. The proportions of this nozzle can be seen from the illustration. A special process is used for forging the nozzle from a single piece of steel by

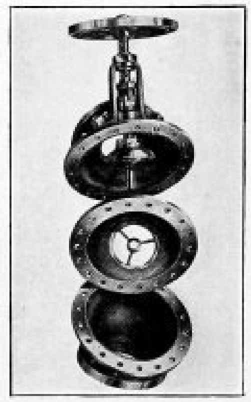


which the neck just under the flange is made heavier than the remainder of the body, thus providing against the working strains which are greatest at this point. The distance between the flanges is sufficient to allow the insertion of bolts from the under side, thus obviating the use of studs. The saddle flange is of sufficient diameter to enable the use of power riveters for attaching the nozzle. The nozzle may be heated and the saddle flange bent to the required circle with no separate part to become loosened when heated. It is claimed that this type of nozzle forms the safest and most reliable connection between the boiler and high-pressure piping.

Patterson-Allen Forged Steel Valve

A special line of valves for superheat and other high-pressure installations is manufactured by the Patterson-Allen Engineering Company, New York. The construction of the valves is shown in the illustrations. They are made entirely from forged steel boiler plate with Monel seats, Monel disks





and nickel steel stems. They are said to be one-third lighter than cast steel valves of equal capacity. The valves are all forged in steel dies, which it is claimed absolutely guarantees uniform thickness throughout, and they are required to stand a hydrostatic test pressure of 1,500 pounds to the square inch.

Circulating Attachment for Dry Back Internally Fired Boilers

John Brennan & Company, Detroit, Mich., manufactures a patented circulating attachment for use with dry-back, internally-fired boilers, to overcome the lack of circulation and to increase the capacity and likewise the efficiency of this type of boiler. The ordinary internally-fired boiler is one that gives general satisfaction, but it lacks the essential qualification of

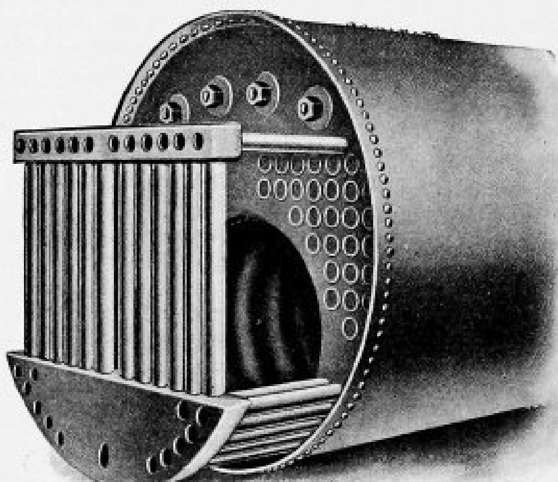


FIG. 1

"functional circulation." This not only cuts down the percentage of evaporation, but when widely different temperatures prevail at different parts of the boiler severe and unequal strains prevail, causing, sooner or later, leaky tubes and rivets. The reason the fault exists in this type of boiler is very clear. The furnaces are located below the center line of the boiler, necessitating a large space below the grate level, or center of the furnace, and this space is occupied by water that is entirely removed from the action of the fire or products of combustion, and consequently must be termed "dead water," the live water being that in which the heating surfaces are active, namely, above the grate level.

To establish a comprehensive idea of the extent to which the boiler is thus affected, one must have a knowledge of the approximate amount of water in question, and to this end the following figures are given: A standard 150-horsepower boiler with one furnace contains about 21,000 pounds of water. Of this 14,000 pounds is live water, or water in direct contact with the products of combustion, while 7,000 pounds is dead water, or water removed from direct action of the fire.

A standard 200-horsepower two-furnace boiler contains about 32,000 pounds of water. Of this 22,000 pounds is live water, or water in direct contact with the products of combustion, while 10,000 pounds is dead water, or water removed from direct action of the fire.

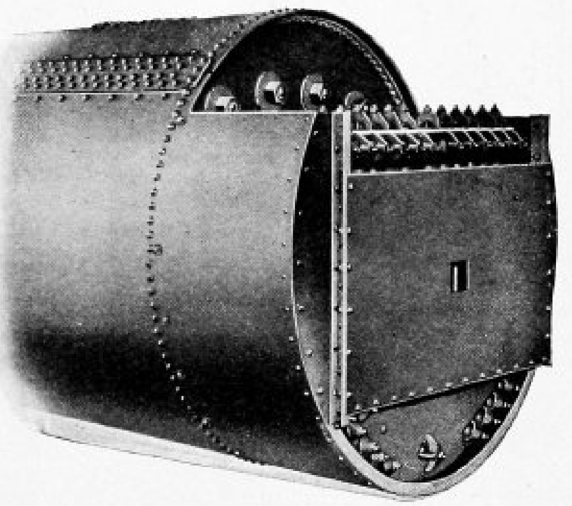


FIG. 2

The above proportions hold good in all sizes of internally-fired boilers, and it will therefore be observed that practically one-third of the total water is dead, and its temperature is low as compared with that prevailing in the live water when the boiler is in service. It is evident that in this type of boiler the one thing needful is automatic circulation, which is sure and positive, and not dependent on an auxiliary boiler or pumps, etc. To accomplish this end the patented circulating attachment shown herewith has been devised.

Fig. 1 shows the boiler ready for brickwork, around and back of the attachment, and Fig. 2 shows the brickwork in and the casing bolted up. It will be noted that the intense heat of the furnace is impinged against the upright tubes in the circulator, and from the moment the water begins to heat it is claimed, the circulation is rapid, positive and continuous over the heated surfaces, thus insuring one temperature throughout the entire boiler, and it is claimed that the frictional action of the water over the heated surfaces of the tubes and headers prevents incrustation, and maintains a state of cleanliness which insures the unimpeded transmission of heat units.

To summarize the claims made by the manufacturers for the attachment are as follows:

(1) It will cause the entire water contents of the boiler to engage in business. It will take possession of the "dead water" (ordinarily one-third of the total), and will set it in motion and make it all live water, and will cause it naturally to travel over and about the most effective surfaces, and will absorb and transmit heat units for working purposes, making all the water of one temperature.

(2) The ill effects of unequal expansion and contraction, due to divergent temperatures, will be prevented.

(3) The temperature will be uniform throughout the boiler during the process of getting up steam, as well as while the boiler is in operation delivering steam.

(4) Efficiency will be improved and the horsepower will be increased in proportion to the additional quantity of water submitted to the influence of fire and heating surfaces while following its cycle of continuous travel.

Personal

JOHN L. FORD, after an extended absence, has returned to Cananea, Mexico, as foreman of the machinery department of the 4-C Company.

J. A. COXEDGE, formerly with the Missouri Pacific Railway at Hoisington, Kan., is now assistant foreman boiler maker for the Santa Fe Railroad at Albuquerque, N. M.

G. E. BROOKSHAW, formerly foreman boiler maker of the Aberdeen & Ashboro Railroad, Biscoe, N. C., has resigned to accept the position of foreman boiler maker for the Georgia Locomotive & Car Manufacturing Company, Albany, Ga.

WILLIAM D. HALKET, superintendent of the Bay City Iron Works, San Francisco, Cal., has returned from a business and pleasure trip of several weeks in the East, during which time he visited New York, Boston, Philadelphia, Chicago and other cities.

CHARLES E. FRICK, for many years general foreman of the Philadelphia Iron Works, has resigned to accept a similar position with the Quaker City Iron Works of Philadelphia. When Mr. Frick severed his connection with the Philadelphia Iron Works he was presented by his former employees with a beautiful stick pin and a pair of link buttons with his monogram.

T. W. HENNIG, formerly of Newton, Kansas, has opened up a general boiler and tank works at Enid, Okla., and will do business under the name of the Enid Boiler & Tank Works. Mr. Hennig announces that he is in a position to manufacture heaters, smokestacks, wheel barrows, tanks, and to do general sheet iron work and also all kinds of repairing.

GEORGE WEAST, head boss machinist; Thomas Cavanaugh, boss boiler maker, and John Butler, boss flanger, have resigned their positions with the Kelly Springfield Road Roller Company, Springfield, Ohio.

EDWARD S. FITZSIMMONS has been appointed mechanical superintendent of the Erie Railroad, with headquarters at Cleveland, Ohio. Mr. Fitzsimmons began railway work in 1890 with the Chicago, Rock Island & Pacific, remaining with that company until 1899. From there he went to the Delaware, Lackawanna & Western Railroad as foreman boiler maker at Scranton, Pa. This company sent him to the Baldwin Locomotive Works in 1904 as inspector of new equipment. In the same year Mr. Fitzsimmons went to the New York, New Haven & Hartford as general boiler inspector, with headquarters at New Haven, Conn., and in the following year he was appointed general foreman boiler maker of the Erie, with headquarters at Meadville, Pa. His promotion to master mechanic of the Cincinnati division of the Erie occurred in 1907, and in the following year he was transferred in the same capacity to the Allegheny & Bradford division, with headquarters at Hornell, N. Y., a position which he held up to the time of his appointment as mechanical superintendent.

JAMES WEIR, formerly connected with the Michigan Central Railroad, has been appointed district locomotive boiler inspector at Louisville, Ky.

H. F. JONES has been appointed foreman boiler maker of the Denver & Rio Grande at Salida, Col., taking the vacancy caused by the resignation of F. J. Gussenhoven.

Communications of Interest from Practical Boiler Makers

Rules for Bracing Boiler Heads

I have just been reading John Cook's articles relative to the area of boiler heads to be braced which were published in the March issue of THE BOILER MAKER. As the finding of the area of the segment of a circle is found to be bothersome by many who have to deal with such matters, Mr. Cook's articles are worthy of more than a casual reading.

The first method he gives (in his article on page 90) is an old one, yet the simplest of all, and sufficiently accurate in its results to suit the most fastidious in boiler calculations. I remember having seen that method of finding the area of a segment published in a mechanical paper about fifteen years ago, but since then I have never seen it before in print until now. I know of several rules and formulas for that work, but not one that is so easy to use and to remember as the one brought to light again by Mr. Cook.

The second rule to which Mr. Cook refers in his article on page 97 is one that appears in the late Charles H. Haswell's "Engineers' Pocketbook." Of course, from a strictly mathematical standpoint this rule would be considered more nearly correct in its results than the others, but for practical uses the first-mentioned method is as good as any other, and for the practical workman, who does not care to store his brain with a lot of formulas, it is much better. Particularly is this true when it is considered that, even in the best of these formulas, mathematically considered, there is a certain percentage of error; besides this, the number of stays figured out for any given head seldom comes out a whole number. For example, the figures may produce, say, seven and one-half stays numerically, and so, other things permitting, eight stays would be used in an actual head to be braced. This shows that extreme precision in finding the area of the segment to be braced is not required, and, therefore, the simpler the rule the better. The boys had better learn that rule for they will need it sometime. CHARLES J. MASON.

Scranton, Pa.

Applying Boiler Tubes

Having read Mr. D. L. Akers' article on applying locomotive boiler tubes and your request on his behalf for some means of keeping tubes tight for more than five or six months. I think that Mr. Akers is doing about all it is possible to do in the careful manner in which he sets his tubes. Possibly brazing his coppers on the ends of his tubes may help a little; outside of that I think that there is no help.

My own experience is very much like Mr. Akers' with engines using water quite clear and, strange to say, good drinking water, but with a very large amount of scale-forming matter, causing the renewals of tubes every six months, and other expensive repairs at short intervals. All repairs were carefully made by a first-class workman, but to no purpose. Something had to be done to cut down the cost of repairs. Having read an extract from a German scientific periodical, recommending the use of a certain quantity of common washing soda as a certain and cheap means of preventing incrustations in steam boilers, we came to the conclusion that we would give it a fair trial. Having just installed a set of Shelby cold drawn steel tubes in one of our engines, the use of the soda was begun in quantities of one pound of soda to every 500 gallons of water used, with the result that at the end of a year there had not been a boiler maker working upon that engine and there was no sign of any scale having formed in any part of the boiler.

I may here say that we prefer common soda crystals to anything we have tried, but care should be taken that the boiler is not overdosed. Its cost is trifling, and its application very simple, and the results are all that could be desired.

Pittsburg, Pa. G. H. HARRISON.

Comment on the A. B. M. A.

Your April number, which carried a report of the proceedings of the A. B. M. A. meeting, was very interesting reading. Your editorial on the same subject was also to the point.

The writer, while connected with the management of boiler shops, is not eligible to membership in the association, but is very much interested in its welfare, for the reason that ultimately we believe the organized body of boiler manufacturers will be the indirect cause of bringing about more desirable conditions in the trade, which at the present time are very unsatisfactory to many, if not all, who have large sums of money invested in the business. It has always surprised the writer why more of the large boiler manufacturers did not join the association. The reasons they give for not doing so puts me in mind of a little story which runs as follows:

Once there was an automobile going along a country road. A skunk in the bushes heard it and ran out and looked after it, and smelled after it. The skunk in a moment turned back to the bushes with the remark, "What's the use?"

If the large boiler manufacturers are asked why they don't join the association, they usually answer, "What's the use?"—evidently assuming that it is not within the province of the association as a body to improve trade conditions, which is probably correct to a certain extent. On the other hand, if every prominent boiler manufacturer in the United States was a member of the association and met in convention once a year, to get acquainted and compare notes, and cultivate a brotherly spirit in business, much good would surely come of it and trade conditions could be improved by legitimate means for the boiler manufacturer, as they have been improved for many other organizations of business men and manufacturers who adopted the "get-together" spirit for the general welfare of all concerned.

Some manufacturers within the past five years, who are doing a very large volume of business, have made comparatively little money—wages may advance and materials may advance, but the price of the commercial boiler is constantly growing less. One concern who did over a million dollars' worth of boiler work each year, probably nearer two millions, made no money for several years, and retired from further activity some little time ago. This should have been a lesson to others, but present indications and the signs of the times are that the lesson was wasted, and will undoubtedly have to be repeated unless present conditions are improved by the only ones who are in a position to improve them—the boiler manufacturers themselves.

It is not for the writer to say just what method may be used to bring out this improvement. It is sufficient to say at present that the method will be evolved if those most interested bury their trifling local differences and petty jealousies and come together like men and face the situation and master it.

It would be much better for all concerned, including the steam user or boiler purchaser, if conditions were different. The large manufacturers who are selling from fifteen hundred to three thousand commercial boilers each year and who have to wait until their inventory is figured up to find out which side of the ledger the account should be placed on, would be very much better off with only half of the volume of business, based on legitimate prices and with an amount of profit commensurate with the efforts put forth, as well as the money invested in the business.

The average steam user or purchaser of a steam boiler would pay a fair price for it if he had to, and, strange as it may seem, it would be beneficial to him to compel him to do so, and incidentally enlighten him as to the possibility of obtaining better materials for boiler construction than was possible a few years ago.

The man who is purchasing a boiler seems to have an easy conscience after he reads the stamp mark 60,000 T. S. which the agent calls his attention to on the shell plates of his boiler; but the agent or the manufacturer who is compelled to use plates having a minimum tensile strength of 60,000 with a possible maximum tensile strength of nearly 70,000 cannot feel as comfortable as he should, knowing that the present conditions of trade compel them to use high tensile plate and a factor of safety sometimes as low as four to meet the demand for cheap boilers that was created by unwise and unholy competition among those who are now feeling the effects of their own errors of the past.

This article is not written with the intent to injure or criticise. The only object of the writer, who is deeply interested in the boiler business, is to stir the thought of the readers of your paper who are in the boiler manufacturing business into activity, so that this branch of the manufacturing industry may come into its own. There will be no trouble about finding ways and means to this end without violating any law or statute.

As a final word, I would say there is no reasonable excuse for a continuation of the present conditions, which are, to say the least, very unsatisfactory; all that is necessary is to bury the hatchet and all meet on common ground at the next meeting of the Boiler Manufacturers' Association at Cleveland in 1913. Let each come prepared to submit some ideas for a solution of the problem of bettering trade conditions among the boiler manufacturers of the United States.

PROGRESSIVE.

Talks to Young Boiler Makers

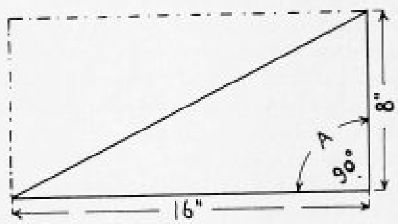
No matter where you go you will find the idea that a boiler maker is about the roughest party to be found; he is supposed to be able to see a rivet hole, when he is sober, and to know enough to put a hot rivet in it and bang up the end, and that is about all. Especially does the machinists' trade look upon a boiler maker as one with only enough brains to go after his pay envelope.

I get red-headed mad on account of this (that is, I would if I had any hair left) injustice to boiler makers, and I enjoy putting it all over a machinist whenever I get a chance. He comes to me with a micrometer and tells me about one thousand parts of an inch, and how close he and all his brothers work. I listen and let him believe that he is a h—— of a fellow, and is the very first pebble on the beach, and I want to sit at his feet and learn, and he swells up, then I tell him I have been banging away at boilers all my life, and want to know how he would lay out this little everyday job, saying, "I have a smoke-stack 46 inches diameter to make, and a pipe from a small furnace has to run into it at an angle of 30 degrees. How can I lay out the hole in the big stack before I roll it up and have the small pipe fit snug?" Well, the machinist just fades away, or he has "just forgotten how he used to do that," and he has to get back to his lathe or planer, that does all his work for him.

Now that I have relieved my mind on this subject I will just add a single word more, and that is, that I know that the boiler maker has no delicate trade, but it takes brains to be a good one, and I know no trade where bad workmanship shows up quicker and any "bulls" he makes will "tell on him" mighty quick.

I started to talk about mathematics; I know fellows get all upset when you begin to talk of mathematics. They are apt to think that only "highbrows" can understand them. I cannot go into the entire subject, but there are a lot of good books that can be bought for little money that go into the subject, and I want to get young boiler makers interested so that they can make some of those high-toned machinists look foolish.

Now a lot of people get frightened at a name. Here is one, "Derconstantinopolishtanisherdudlesackphipergesselerhauptman." They tell me all this only means "The captain of the Constantinople Bag Pipe Society." It ought to mean a lot,



RIGHT TRIANGLE

and if anybody can make more noise than a boiler maker it would be a bagpiper. Some fellows have a "duck fit" when you say "hypotenuse" to them, yet it only means the longest line in a right triangle. The word "trigonometry" sounds hard, but it only means "measuring angles."

The use of triangles comes in very handy for a boiler maker, and here are some things about them. The triangle shown in the sketch has a right angle *A*. This angle is also called a 90-degree angle. If you multiply 90 by 4 you will have 360. For convenience a circle is divided into 360 degrees, so 90 is one-quarter of a circle. All right angles are equal, no matter whether it is in the dices you get stuck for drinks with or the right angle of the block you live on; the right angles are the same, only the block has longer sides than the dice. Often you want to know the number of square feet or inches in a right-angle triangle, and it is easy to find them.

In our sketch one of the sides is 8 inches long and the other is 16 inches long; you multiply these two together and you have $16 \times 8 = 128$; this you divide by two, and you get 64, which is the area of the triangle.

To make this clear to you I add to the right-angle triangle dotted lines, which, with the solid ones, will form a square, or rather a parallelogram. In my last talk I told you about calculating areas, how length by breadth gives surface, and it is plain to be seen that if you draw a line from corner to corner you will have cut the square into two equal parts, and one of these is the right-angle triangle.

We know the length of two sides of the right-angle triangle, now we want to find the length of the diagonal line or hypotenuse. What we do is to multiply the length of each side by itself; square it as I explained in my last talk, and add the two results together, $8 \times 8 = 64$, and $16 \times 16 = 256$; added together we have 320. Now comes the hard part; we have to find the square root of this number. I cannot now describe how to do this, but there are tables of square roots, and in them we will find that the square root of 320 is 17.87, and that is the length of the diagonal line.

This triangle subject is one which forms in mathematics the most interesting of all its branches, and is by far the most practical of them all for the boiler maker, and we will go into it more fully later, but no one must get scared over names.

F. ORMER BOY.

How to Find the True Length of Circular Courses of Plates

In the January issue of THE BOILER MAKER, I notice an article requesting that some reader give the true method of ascertaining the true length of circular courses of plates and angles; i. e. angle-bars.

Assuming that the stack referred to was about to be repaired, and several new courses were to be added, the safe and proper way to obtain the true length of the plate is to find the diameter. I have never failed to get the diameter by simply obtaining the length of the ring outside with a tape, and dividing by 3.1416. This result is the outside diameter. The neutral diameter can be determined, by subtracting the thickness of the material to be used on the new work, from the diameter as obtained above. This neutral diameter times 3.1416, is the true length of the course desired.

This applies to a tapered course as well as a straight course. The outside diameter of the small end of a tapered course, on work that is not irregular, is the same as the inside diameter of the large end, and one should not experience any difficulty in obtaining this.

The true method of obtaining the length of angle bars has been explained in my last contribution.

There are, at the present time, very many different ways employed in obtaining the length of circular courses of plates, which should not under any circumstances be taught to the apprentice; such as multiplying the inside diameter by 3.1416 and adding 7½ times the thickness of the material employed to the result. I have even witnessed foremen employing the above method. Now let it be understood that there is but one correct way to find the circumference of a circular plate course, and that is by multiplying the neutral diameter of the ring by 3.1416, or 3.14159; the former, however, being the standard for all practical purposes.

I would not advise the use of a measuring wheel on very accurate work. A good tape is more accurate on all work.

Albany, N. Y. J. F. HAVLAK.

Simple Layouts

Mr. J. T. Bradbury's remarks in THE BOILER MAKER for March are very timely and bear the imprint of a long experience. The apprentice of to-day should take his advice to heart and begin to dig, for the apprentice of to-day has opportunities that were denied to us beginners some years ago.

I submit two sketches which, although very simple, are among the first steps in laying out.

Fig. 1 represents a piece of work generally used as a shield or cover. Begin by erecting a right angle, as *A B R*, Fig 2. Make *A B* equal to the straight height of article, set off *B R* equal to the length of the side at the bottom, connect A R, which gives us the slope length if the plate required.

Erect the rectangle *A A B B*, equal in width to *S S*, Fig. 1, and equal in length to *A C R*, Fig. 2. Set the dividers to *A B*, Fig. 2, and strike an arc from *A* and *A*. Set the dividers to *B R* and strike arcs from *B* and *B*, intersecting the arcs already struck, connect up with lines and the pattern is complete.

Fig. 4 shows a hopper or sheet. Draw up the elevation as in Fig. 5. At the base draw the half circle, or half diameter required, divide it into equal parts and strike lines to the base, as shown. Set a square to point 1 at the top, and draw line 1 *A*. Set off a quarter circle and divide it into equal parts as at the bottom. The top in this case is of the same width as the bottom, the ends being half circles equal to the bottom diameter. Connect up all points with lines as shown. At any point on line 1 1 square off line 1*B*, from which line set off the lines in the quarter circle at the bottom. Connect up these points and we have a profile, from which we get the girth of these two ends at point 1 on bottom square of line 1 *C*.

Now, to develop the pattern, erect perpendicular 1 1, Fig. 6, on each side of this square off *F* line o o. On this line on each side of 1 1, set off the distance from the profile, as from 1 to 2, 2 to 3, 3 to 4, and 4 to 5. From these points erect perpendiculars, and on the lines thus drawn, set off the lengths of lines in Fig. 5, from line 1 *G* to line 1 *D*. Below line o o set off the distance found below line 1C, Fig. 5. Correct up all points with a fair curve. Now from point *D*, Fig. 5, set dividers to *E*, carry this distance to points 5 5, Fig. 6, and strike arcs

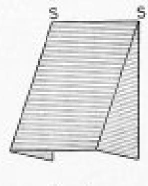


Fig. 1

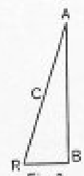


Fig. 2

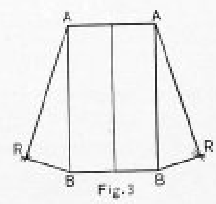
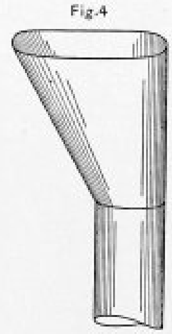
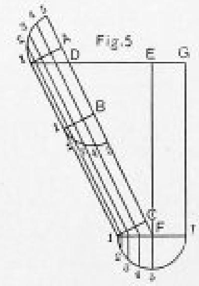


Fig. 3

Fig. 4





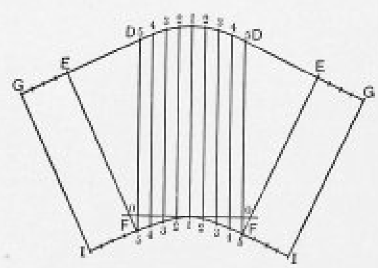


FIG. 6

at *E E*. Set dividers to *E F*, Fig. 5, and from points *F F*, Fig. 6; strike arcs intersecting *E E*. Connect up with lines and this will give us the triangular-shaped section of the article. Now set a square to the lines *E F*, and produce *E G* F and I, making this equal in length to one-fourth of the circle. Connect up with lines as shown and the pattern is complete to the rivet line, the lap, of course to be allowed. Care should be taken to draw all plans and elevations to the neutral diameter of the article required. J. SMITH.

Obituary

HENRY SMITH ROBINSON, president Atlantic Works, East Boston, Mass., is dead at the age of 81 years. He was born in Merideth, N. H., Jan. 22, 1831. In 1847 he became assistant engineer for the Hamilton Manufacturing Company, Lowell, Mass., and was made engineer of the York Manufacturing Company, Saco, Me., in 1849. He had charge of the steam department of the Pacific Mills at Lawrence, Mass., from 1864 until 1873, when he established the Robinson Boiler Works at East Boston. In 1892 the plant was destroyed by fire and the business was merged with that of the Atlantic Works, of which he became president in 1898. He served in the navy and afterward in the army in the Civil War.

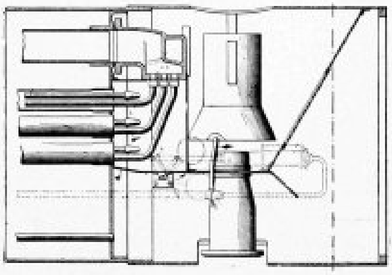
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
Loan and Trust Building,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,011,197. DAMPER FOR LOCOMOTIVE SUPERHEATERS SIMON HOFFMANN, OF NEW YORK, N. Y., ASSIGNOR TO LOCOMOTIVE SUPERHEATER CO., OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 2.—In a locomotive provided with a blower and a superheater of the class described, the combination of a casing at one end of the boiler around the superheater pipe ends and their fire tubes, a normally



open damper in said casing, and a steam cylinder having steam connection to the blower and provided with a piston connected to the damper for closing the same. Four claims.

1,011,270. WATER-LEVEL INDICATOR. CHARLES A. TANNER AND ALBERT P. SAXER, OF PITTSBURG, PA.; SAID TANNER ASSIGNOR TO PITTSBURGH GAGE & SUPPLY COMPANY, OF PITTSBURG, PA., A CORPORATION OF PENNSYLVANIA.

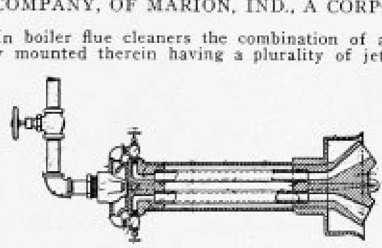
Claim 7.—In a water gage, the combination of two fixtures each provided with a chamber and with a lateral sleeve communicating with said chamber, a glass tube connecting said lateral sleeves, a check valve in each of the fixtures arranged to close communication through the chambers therein, the check valve of the upper fixture being provided with a by-pass, and a whistle located in the upper fixture between said check valve and the upper end of the glass, whereby when the glass breaks the steam escaping through the by-pass and broken glass causes an audible alarm. Seven claims.

1,012,411. STEAM-BOILER GAGE. JOHN A. MOORE, OF WINSTON SALEM, N. C.

Claim 1.—In a boiler gage, a gage tube associated with the boiler and having gage cocks and an indicating scale, an auxiliary tube, valved ducts connecting the auxiliary tube with the upper and lower ends of the gage tube, a head at the upper end of the auxiliary tube having a gland, a float within the auxiliary tube, a rod associated with the float and extending through the gland, said rod being provided at its upper end with a lateral extension having a downwardly extending arm, and a pointer carried by said arm. Two claims.

1,012,533. BOILER-FLUE CLEANER. HENRY L. ERLEWINE, OF MARION, IND., ASSIGNOR TO CENTRAL MACHINE & FOUNDRY COMPANY, OF MARION, IND., A CORPORATION OF INDIANA.

Claim 1.—In boiler flue cleaners the combination of a fixed shell, a head rotatably mounted therein having a plurality of jet passages with



jet openings of different eccentricity, a steam inlet communicating with said passages and a plurality of valves carried by said head and each controlling one of said passages. Six claims.

1,012,484. SMOKE-CONSUMER FOR LOCOMOTIVES. WALTER SEAVERNS WAIT, OF NEWTON, MASS.

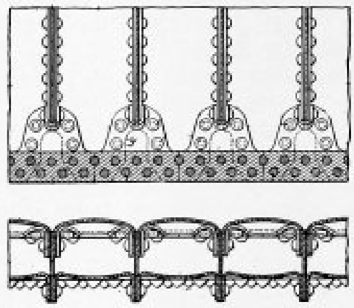
Claim.—A combustion apparatus comprising a fire-box, a smoke-box, a pipe leading from the smoke-box to the fire-box and arranged to receive cinders and other products of combustion entering into the smoke box and deliver them into the fire-box, an injector arranged in said pipe, a steam chamber, connections between said steam chamber and said injector whereby the passage of steam out of said injector creates and maintains a draft through said pipe from said smoke-box into said fire-box, an air inlet arranged in said pipe, a delivery pipe connected to said steam chamber, and a pipe leading from said delivery pipe and adapted to supply steam to said injector to automatically maintain the action of said injector with relation to the passage of steam through said delivery pipe. One claim.

1,012,327. ADJUSTABLE SUPPORT FOR FLUE CLEANERS. CHARLES C. CHAMBERLIN, OF WASHINGTON, PA., ASSIGNOR TO MARION MACHINERY FOUNDRY & SUPPLY COMPANY, OF MARION, IND.

Claim 5.—The combination with a boiler and a steam supply pipe leading therefrom, of swivel members supported on said steam supply pipe and each provided with a pipe section extending at substantially right angles thereto, and connecting with said steam supply pipe through said swivel members, and a boiler flue cleaner carried by said pipe sections. Eight claims.

1,012,358. BOILER FIRE-BOX CONSTRUCTION. CHARLES L. HUSTON, OF COATESVILLE, PA., ASSIGNOR TO JACOBS-SHUPERT U. S. FIRE-BOX COMPANY, OF COATESVILLE, PA., A CORPORATION OF PENNSYLVANIA.

Claim 1.—The combination in a fire-box, of flanged fire-box lining plates; a mud ring and coupling plates at the junction of the lining



plates with the mud ring; and secured to both the mud ring and to the said lining plates. Seven claims.

1,012,301. SPARK ARRESTER. THOMAS M. VAN HORN, OF CHICAGO, ILL., AND LOUIS E. ENDSLEY, OF LA FAYETTE, IND., ASSIGNORS, BY DIRECT AND MESNE ASSIGNMENTS, TO AMERICAN SPARK ARRESTER COMPANY, OF INDIANAPOLIS, IND., A CORPORATION OF INDIANA.

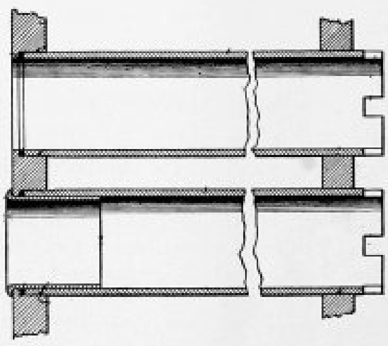
Claim 1.—The combination with a steam boiler provided with a smoke-box, a smokestack leading therefrom, and an exhaust steam jet discharging upwardly toward said smokestack, of means arranged in the smoke-box for causing the exhaust gases to make one or more vertically disposed revolutions in the smoke-box before reaching the smokestack, and a receiver in the lower part of the smoke-box between said centrifugal means and the exhaust jet for receiving the heavier particles. Four claims.

1,012,263. BLOWER FOR BOILERS. ALFRED G. MATTSSON, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY COMPANY, OF DETROIT, MICH., A CO-PARTNERSHIP.

Claim 2.—The combination with the breech-door of a boiler, of a flue-blower comprising a jet pipe extending through said door, a bracket rigidly attached to said door and pivotally supporting one end of said pipe on the outer face of said door, and means for swinging said pipe laterally and in a substantially horizontal plane. Seven claims.

1,012,258. BOILER FLUE. JOHN W. JOHNSON, OF TRENTON, MO.

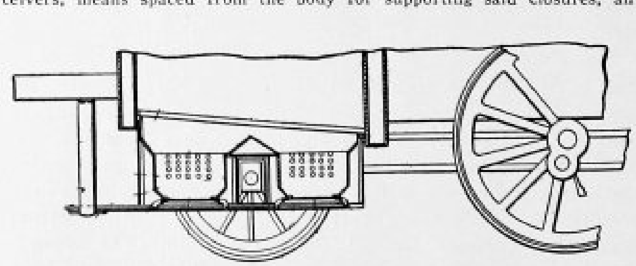
Claim 1.—In boiler construction, a flue sheet formed with an opening having a shoulder at its edge presented toward the inner face of the sheet, a packing gasket disposed within the opening and against the



shoulder, a flue threaded into the opening and abutting at its end against the said gasket, and a thimble pressed into the opening of the sheet beyond the gasket, the outer end of the thimble being spun to cover the rim of the opening in the sheet. Two claims.

1,012,215. ASH-PAN FOR LOCOMOTIVES. LOUIS S. MOORE, OF MONTGOMERY, ALA., ASSIGNOR OF FOUR-FIFTHS TO J. I. McKINNEY, L. C. CAMPBELL, J. E. STEVENS, AND WASHINGTON ELDRIDGE, ALL OF MONTGOMERY, ALA.

Claim 2.—An ash-pan for locomotives, including a body having spaced ash receivers depending therefrom, each receiver being open at the bottom, slidable closures normally contacting with the bottoms of the receivers, means spaced from the body for supporting said closures, an



actuating bar extending under and connected to the closures, said bar being spaced from the closures, a lever pivotally connected between its ends to the bar, and means removably engaging the lever for shifting said lever and bar to simultaneously open or close the closures, said closures being movable together in the same direction. Two claims.

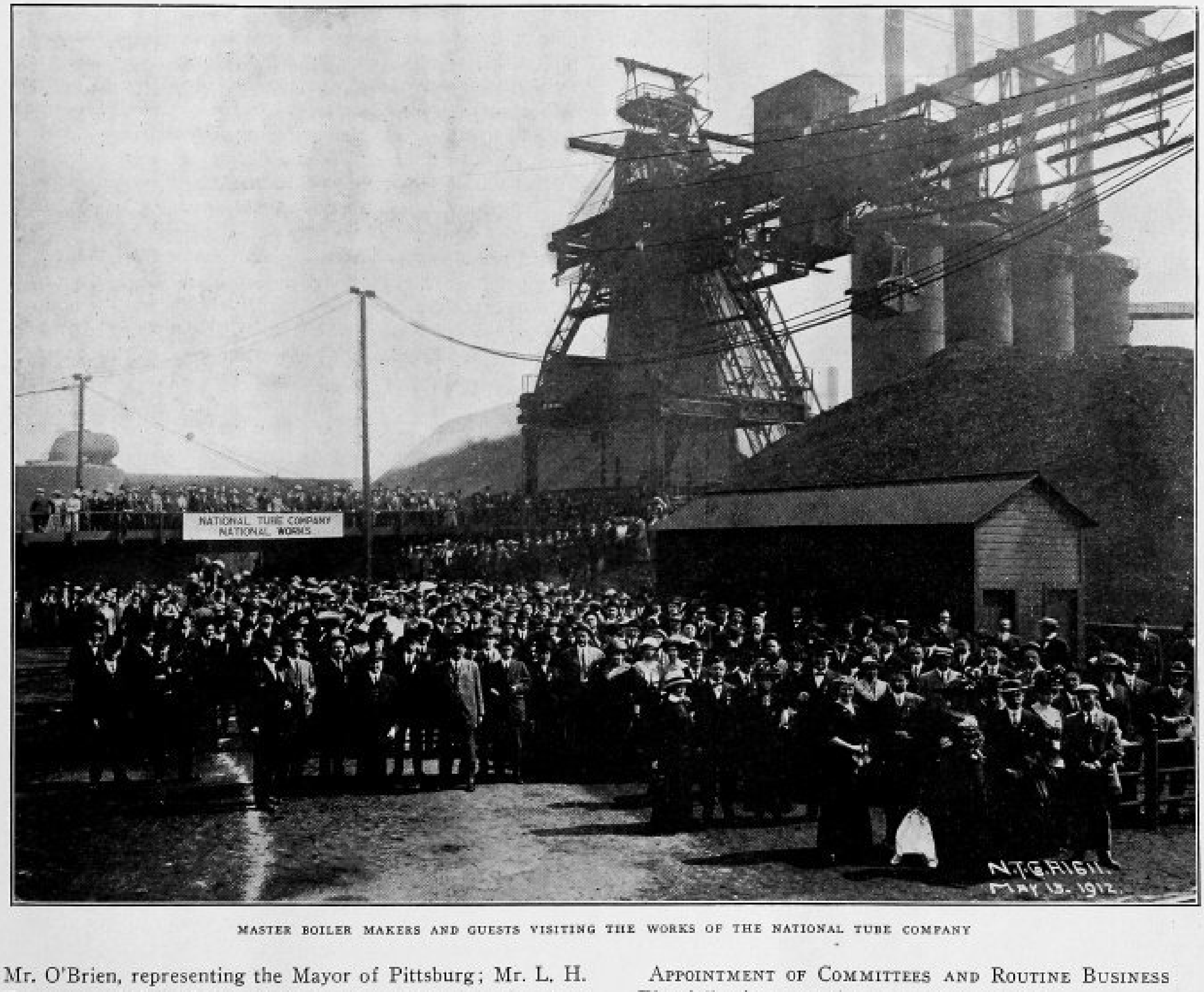
THE BOILER MAKER

JUNE, 1912

Master Boiler Makers' Sixth Annual Convention

The sixth annual convention of the Master Boiler Makers' Association was opened Tuesday morning, May 14, at the Fort Pitt Hotel, Pittsburg, Pa., with the president, Mr. George W. Bennett, in the chair. Prayer was offered by Reverend Father O'Connor, and after the invocation addresses were made by Mr. O'Brien, representing the Mayor of Pittsburg; Mr. L. H. Turner and Mr. McConway, representing the business interests of Pittsburg, and Mr. James F. Deems, formerly superintendent of motive power New York Central Lines. Responses to these addresses were made by Mr. O'Connor, Mr. T. W. Lowe, Mr. George Wagstaff and Mr. W. H. Laughridge, all prominent members of the association.

After the addresses of welcome the president of the association, Mr. George W. Bennett, delivered his annual address, reviewing the work of the association, its constant growth and opportunities for future development. The president's address was followed by reports from the secretary and treasurer, showing that the affairs of the association were in an extremely satisfactory condition.



MASTER BOILER MAKERS AND GUESTS VISITING THE WORKS OF THE NATIONAL TUBE COMPANY

Appointment of Committees and Routine Business

The following committees were appointed:

Auditing Committee—John J. Smythe, W. H. Laughridge and J. J. Mansfield.

Committee on Resolutions—George Wagstaff, G. F. Graves and John Tate.

Committee on Memorials—Charles P. Patrick, John German and J. J. Casey.

An acknowledgment was sent to Governor Foss for his courtesy in sending Mr. Joseph H. McNeil, chief boiler inspector of the State of Massachusetts, to the convention, and the privilege of the floor was given to Mr. McNeil.

It was voted that Mr. C. P. Patrick should attend the Sixth Congress of the International Association for Testing Materials in New York, Sept. 3 to 12, as a representative of the association, and also that a representative should be appointed to attend the Third National Conservation Congress, Kansas City, Mo., Sept. 25 to 27.

TUESDAY AFTERNOON SESSION

Feed Water: Location of Admission and the Results Obtained*

The general practice followed in feeding locomotive boilers with water is to inject it through one of four different locations, viz.: (*A*) On the front course of the barrel with individual checks about both side centers; (*B*) on the same course with duplex checks on the bottom center, and (*C*) on the top center, as well as (*D*) with individual checks located on the back head of the boiler, provided with internal pipes discharging the water near the front tube sheet.

GEO. BENNETT, RETIRING PRESIDENT

The common practice is to have feed water enter the boiler in a solid stream, at a low temperature. We think it is pretty well conceded that, on account of feed water being cold and at a lower temperature than the water in the boiler, the uneven temperature causes an undue contraction and expansion of the fire-box sheets and bottom flues, these conditions causing, according to local conditions, leaky boilers, premature damage to materials, and also expense in remedying these defects.

Some roads use a deflecting plate on the inside of the boilers in order to deflect the water up over the flues after it enters the boiler, thereby preventing the deposit of scale on the inside of the shell, between the shell and the flues, which is a source of some trouble and shows some improvement, but still curtails the life of fire-boxes and does not prevent engines from leaking.

Another device used to some extent is the upturned elbow in the boiler check. An upturned elbow with a contracted nozzle has been found to be a simple and effective device for equalizing the temperature of feed water, but as near as we can find out it only brings about a difference of 15 degrees between temperature at top and bottom of the boiler.

A more recent device for delivering feed water to a locomotive, and a radical move in the location of boiler checks, is the "Phillipps" check. The feed water is delivered in a solid stream in the steam space. There is also on the market another device, known as the Seddon Boiler Feed Device, which was designed and patented by Mr. C. W. Seddon, S. M. P. and C., for the Duluth, Missabe & Northern Railway Company. This device presents an entirely new idea. The feed water is discharged into the steam space in the shape of a spray; these small drops absorb the heat and fall to the surface of water in the boiler at a uniform temperature. This method causes incrusting solids contained in the water to separate before it mingles with the boiler water, and these solids are collected in a sediment pan, thereby leaving sheets and tubes free of scale. Another feature of this sediment pan is that the feed water is held in suspension before being allowed to mingle with water below, until it overflows flange at rear of pan; this is double assurance of feed water getting heated to the same temperature as water already contained in the boiler.

One railroad has ninety-six engines equipped with the "Seddon Boiler feed Device," and the records show some very gratifying results from its use; noteworthy is the 50 percent decrease in boiler maintenance, the increased life of fire-boxes and flues, and the elimination of failures due to boiler troubles.

Without advocating any special device or location for admission of feed water, we wish to say that it remains an undisputable fact that this location should be such as to eliminate entirely the damage to boilers, which is caused by delivering water of lower temperature than that contained in boiler.

While the water raised by an injector will rise in temperature, tests made years ago show that it will drop to the bottom of boiler, because of its specific gravity. Enginemen often are careless in the handling of injectors, not realizing the damage caused by flow of cold water. Another point which we wish to bring out is the fact that 90 percent of boiler failures can be traced below the boiler checks. Our idea is to feed the water in the boiler just as high as we can and spread it as much as we can; if any of the members will try this out they will be very much impressed with the results obtained.

To determine the most desirable location for the admission, a ten minutes' temperature test was conducted under three of the methods of feeding and like conditions mentioned in the forepart of this report. In our opinion feeding from the top, near the front tube sheet, is the most desirable location for locomotive boilers, because we find the mud and scale better distributed throughout the barrel of the boiler and less lime and magnesia deposits are found adhering to the pressure side of the fire-box plates than when feeding from any other location, and this appears to be why better results are obtained.

Mr. Schaule: We have all our engines equipped at the present time with the raised feed water and are getting excellent results. Before this raised feed water was arranged for we had four or five boiler makers in the round house; since applying this raised feed water we only have two, one at night and one at day, and most of their work consists of ash-pans, grates and broken stay-bolts. We have two kinds of feed devices. We have the Phillips feed water, that is applied on top of boiler, about 36 inches back of front flue sheet. This water is injected into steam space, and we have had good results from this feed water. We have also the C. W. Seddon feed water. This water is injected into boiler just above top quarter line on front course of boiler with a copper pipe leading into boiler. This copper pipe is perforated on top. When water is injected into boiler it comes out in a spray. We have also a sediment pan underneath our feed water. The

* Abstract of committee report, D. G. Foley, chairman.

back dash on the pan is 2 inches higher than front dash, where water overflows at front end, where all sediment and solids collect. I have taken out a great many sets of flues since we have installed the raised boiler feed and we have had excellent results. The raised boiler check or feed water has raised the tonnage from 1,700 tons to 2,600 tons, and decreased the boiler failures from fourteen to two, and reduced the boiler expenses 50 percent—from 5 to 2 percent. You inject your feed water up into the steam space as high as possible. Have some contrivance—we've got the pan—to keep that water in suspension as long as possible, so it will overflow at front flue sheet, and there is no doubt in my mind, gentlemen, that you will have the same results that we have had on the Dubuque & Northern.

Mr. Newgirg: I made a test on the Chicago & Northwestern, running Boone and Omaha, on a Seddon feed-water device, with two engines of the same type, running on the same kind of a train. In nine months the device decreased the flue and side sheet leaks one-half from where we were using the old style feed-water device.

Mr. Lowe: In the Pacific type of engine, operating on the Brandon section between Winnipeg and Brandon, which is considered a very bad water district, magnesia and sulphates of lime predominating on the inner side of the sheet, when we were using the check on the bottom, we only got a life of about nine months out of side sheets. We made some temperature tests with a view of finding out just where the best location for the admission of water was, and the result of that test led us to supply the water from the top with duplex checks, and we have got two years' life from those side sheets where we got only nine months before. Now I want to give you an illustration of probably why that results. We all know very well where the water contains lime and magnesia of a very hardening—in fact, a flinty—nature it gathers up against those sheets in the fire-box, and that the lime has an affinity for the fire, and if we can raise the temperature of that water before it reaches the fire-box we certainly separate a great portion of that. Therefore, if a greater amount of scale is held up at that smoke-box end you will certainly reduce the evil at the fire-box end because of that. I don't think, myself, that there is any great advantage in it with reference to taking out impurities which are of vegetable or organic matter, but where there is scale of lime and magnesia formation you certainly will increase the life of your side sheets and also your tube sheets and your tubes.

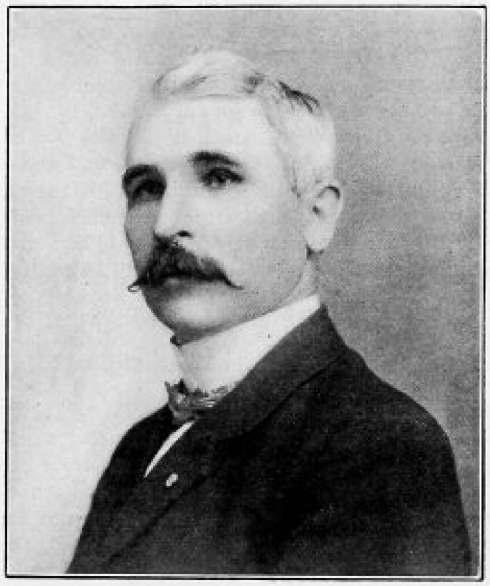
The Chairman: Water admitted at the top goes down to the bottom of the shell, around the mud-ring, and circulates around the fire-box; that takes the place of the water around the fire-box, and when admitted at the top the water is so much hotter when it gets back to the fire-box that it does not do the damage to the fire-box sheet that water would if admitted on the side.

Mr. Schaule: Formerly we had to take out our flues every year, but since applying these boiler checks we have only had to take them out every other year, a bunch of about sixty or seventy flues, to clean the mud out of the boiler. There isn't anything ever put on a boiler that I consider better than the feed-water check up in the steam space; anything to keep your water in suspension before it mingles with the water in the main part of the boiler, and you are going to get good results, because it stops circulation to the back fire-box sheet, and your mud will all settle in the front end; that is the result we have had.

Mr. Lucas: We wash all our locomotives from the front end weekly, and get a good deal of that sludge out of there from the flue sheets. We believe that washing from the front end is one of the best features we've got.

Mr. H. J. Wandberg: We are running three engines for a test with the top feed and have practically no trouble with the flues leaking, but we have some trouble with the scale accumulating on the first two top rows of flues, and we have six washout plugs in the front end of these engines and wash them thoroughly. Some are washed once every trip, which will mean three every 300 miles; others will go 600 to 1,000 miles; the two top rows of flues will be coated over solid about halfway back, but with the class of engines we have these checks on there's very little trouble to clean them off; all you have got to do is to take out the standpipe cover and get down and clean them out. They are certainly, I consider, the best things ever put on the boiler.

Mr. M. O'Connor: I don't see the necessity of having to let mud remain there as long as it does. Now I would think that an automatic blow-off right back of your front flue sheet, by using the automatic blow-off, would keep a good deal of that mud clear. We use the automatic blow-off on our side sheets outside, and that keeps that portion of the box clean, and the same process could be applied right underneath your cylinders,



M. O'CONNOR, THE NEW PRESIDENT

to use an automatic blow-off cock and pull that scale right down.

Mr. Conrath: The overhead feed appealed to me in the very first place as being good, regardless of what way the water is fed in, as long as it is fed in the steam space. If there is any accumulation in the water it is going to deposit into the boiler, and when it gets into the boiler the best place to put it would be away from the fire as far as you can get it, and this can be done if the proper method of feeding is used. Undoubtedly you will agree with me that practical men in the boiler line have always found that accumulation in the fire-box or on the fire-box sheet in the water space is very detrimental. Now, in feeding this water in the Seddon device that Mr. Schaule spoke about they have a perforated pipe. There is a flange riveted in the boiler up in the steam space; it is much thicker on the top side; to make it parallel with the boiler they have a reducer, you might call it, which the pipe is screwed into, then the reducer and all is screwed into this flange so that you can remove that at any time and clean it out. The pipe is perforated from the center line around to the other side, so that the water coming in through that pipe will spray right up into the steam, and spraying up in small particles will heat and maintain a more uniform temperature—a thing which I believe is a good idea. Somebody suggested how would it be if we tried and fed them in the steam space or up on top. There was objection offered; they stated they didn't think it would work and that it would reduce the steam, etc.; but we finally tried the feed on top and our troubles were practically eliminated as far as the leaks in the seams were concerned, and that proves that there's something in feeding the water up higher, and I believe that the experiments made on different railroads will prove this to be a fact.

Apprenticeship*

In the present age scientific methods of production are becoming more important in every industry, and consequently a more thorough training is essential for the apprentices, or beginners, in any industry. In the Altoona shops of the Pennsylvania Railroad the apprentices work in the shops with skilled mechanics, and also during working hours, while under pay, they receive instruction in the shop schools from experienced teachers who have a thorough knowledge of the trade and an interest in the welfare of the boys. This system produces mechanics who are skilled, loyal and efficient. It is considered an essential and highly valued result to so train the apprentices that they can read drawings intelligently and take hold of a great variety of jobs at a moment's notice as they may happen to come up in the shop. Loyalty is increased by raising the apprentices' interest in their work, by co-operation and by cultivating the proper attitude with the employers. This course of training makes the men ambitious to make good use of their time out of the shop. There are 250 apprentices in the Altoona shops covering all the trades involved in railroad shop work.

When is a Boiler in its Weakest Condition?†

A boiler would be in its weakest condition when the plates, bolts, braces or rivets of which it is constructed would become weakened to such an extent that the internal force or pressure would equal the tensile strength of the material at the weakest section or sections. In this condition, strains due to varying temperature would cause a rupture of plates and an explosion, the volume and destructiveness of which would be in accordance with the size of the boiler and the pressure carried therein.

The moment a boiler is placed in service it gradually becomes weaker, due to the destroying forces continually acting upon it. These forces are of both a chemical and mechanical nature. Corrosion and oxidation are continually acting on the material from which a boiler is constructed, and take place both internally and externally, these being the two most serious and subtle causes of weakening to which a boiler is subjected. Evidence of the two above causes are most noticeable in the groving and pitting of plates, and more especially at locations most subject to deposits of mud, scale and organic substances. Expansion and contraction also pay a very important part in the destroying and weakening of a boiler, more especially when concentrated at any one point, such as at sharp bends or flanges in the plates where the inner and outer sheets are subjected to different temperatures, causing an unequal expansion. Constant working or bending of bolts, flanges or angles, sooner or later, however slight, will destroy the fibers in the material at points subjected to it, causing crystalization, cracking, and leaving same more susceptible to the chemical action of the feed water.

It is therefore obvious, in your committee's opinion, considering the numerous ills which a boiler is heir to, that only by thorough inspection by competent inspectors who thoroughly understand the construction, the nature of defects, and the remedies to be applied, can a boiler be maintained in a safe working condition.

In conclusion, your committee wishes to state that in their opinion the elastic limit of the plates, braces, etc., used in the construction of a boiler should be considered, rather than the tensile strength in maintaining boilers in safe working conditions.

The report was accepted without discussion and the committee discharged.

Spark Arresters in Locomotive Engines and Smoke Prevention*

The best design of spark arrester, or front end arrangement, that I know of is what is known as the Master Mechanics' self-cleaning front end. There is a strip of wire netting extending across the diaphragm plate, 10 inches wide and 4 feet 6 inches long. This feature has proved very effective in the drafting arrangement, especially in keeping a live fire at the back end of fire-box. The size of wire netting used for this purpose, and also for spark arresting, is 0.095 wire crimped both ways, mesh three per inch. Another advantage in this style of front end is that it avoids the burning of the front door and door rim on the front of the engine. Also with this style of front end arrangement we have turned out of our shops at Sayre some new engines during the past year without applying the cinder hoppers, which is a big gain, as these cinder hoppers are a source of trouble, on account of admitting cold air into the smoke-box. Unless we can get the co-operation of intelligent firing and proper manipulation of the locomotive, the best results cannot be obtained.

The best method for the prevention of smoke from soft coal is a clean, thin, level fire, fed by what is known as the one-shovel system; that is, a shovel or two at a time.

A number of years ago this method was successfully adopted on a Western railroad. Some of the engines were equipped with a brick arch; the majority had no arch or other device for the prevention of smoke. The process was equally successful on all classes, either with or without an arch; its success depending almost entirely on the judgment and skill of the fireman.

A smoke consumer is successfully used on the Illinois Central Railroad, in which from two to four 2-inch tubes are applied to either side of the fire-box, about 24 inches from bottom of ring, in boilers having a short leg. In deep boxes the tubes are located on a line with the lower flues. The steam jet induces a current of air through the tubes, aiding the combustion of the gases and carbons.

The report was accepted and opened for discussion.

Mr. Schaule: I would like to know which end will throw the most sparks?

The Chairman: Years ago they used to have a long extension front end some 5 or 6 feet long, and they would have castings on the bottom and holes on the side to remove the accumulation of cinders, and if you didn't remove them at the terminal the next trip there wouldn't be any more; they'd fill up so much and then commence to clean themselves. The master mechanics, in their report on that question, have done away with the castings on the bottom of the smoke-box and also on the side, and have got now what they call a self-cleaning engine. We had it before when they had the device for removing the sparks at the end of the trip, and if they didn't remove them at the terminal they would fill up just so far, as I said, and then commence to clean themselves. The openings in the netting must be of a certain size to allow the cinders to get through the netting and out into the atmosphere, because

* Abstract of address by Mr. J. W. L. Hale, head instructor, School for Apprentices, Pennsylvania Railroad, Altoona, Pa.

† Abstract of committee report, J. T. Johnston, chairman.

* Abstract of committee report, Thomas Lewis, chairman.

SIXTH ANNUAL BANQUET OF THE MASTER BOILER MAKERS' ASSOCIATION AT THE FORT PITT HOTEL, PITTSBURG, PA.

that proves itself when you look at these front ends now with no device on them for removing the sparks, and engines will now run from one month to the other without opening the front door and removing the sparks—that's what they call the self-cleaner. On engines going through the woods down in the Adirondacks, we have had considerable trouble due to fires set from the locomotives, and we have tried all sizes of wires, some with three meshes to the inch and one with four; the standard netting we use on engines in the woods is two and a half mesh to the inch, No. 11 wire, and up to the present time we have been getting good results from it. A couple of years ago the damage to the woods from fires ran up into the hundreds of thousands; last year the damage from fire was somewhere about $10,000, hardly anything compared to what it had been in previous years.

Mr. Rearick: About six months ago we equipped every engine on the road with a self-cleaner except one or two. We put in our deflector pipe, and used to run it back of the exhaust pipe; ran the plate out solid in front of the exhaust pipe and ran our deflector plate so that the draft will hit the smoke-box front and give it a chance to get out. When we had the deflector plate back of the exhaust pipe there was not enough draft to send it forward to break those cinders; the result was they lay there and couldn't get through the netting. By this plan they are kept in constant action the whole time and are bound to go through, and since we started to install them we haven't had a hot front end. We have no casting on the bottom.

Mr. Ewell: On the Boston & Maine system there is no such thing known in the last five years as the nail pot, the casting on the bottom. What we use on the Boston & Maine is perforated steel with a three-sixteenth of an inch opening, about an inch and a half long, and it's a rare occasion when they have any fires on the road; the only occasion is when they have an opening in the steam pipes or netting. It is three years, to my knowledge, since they dropped the wire mesh and adopted the perforated steel plate.

Mr. Schaule: Which is giving the best results, the perforated steel or the netting? We are using perforated steel altogether on the road I am connected with.

Mr. Fay: On the Nickel Plate we use what we call the brick arch, and use two and a half mesh netting and what they call a basket netting. It is a very easy matter to put in; it is a cheap concern, and at the same time it is an easy thing to put in, and we also have a smoke burner on the side of the fire-box about 8 inches above the grate, and it's got an opening in the door of about 10 inches, and the fireman when he puts the coal in—one or two scoops (shovels)—he puts his foot on this treadle and opens that opening in the fire-door. If he admits the air into the fire-box with the steam when he puts his foot on this treadle it opens the valve of the steam-box inside the fire-box, and I think that is a very good prevention, and we haven't had any trouble to speak of with regard to smoke prevention. In Chicago we have had very few fines to pay in the last year, owing to this smoke device that we put on our engines.

The discussion was closed and the committee discharged.

What Can Be Done to Produce Better Circulation in Marine Return Tubular and Vertical Boilers?*

Circulation of water in a steam boiler is caused by the difference of density of the water, due to the difference in temperature, which ranges from that of the feed water to that of the uprising steam bubbles as they reach the surface of the water and liberate their steam. The self-rising current of steam bubbles is accompanied by a downward current of water to supply its place, which causes a continuous movement of the water wherever and whenever it comes in contact with the water-heating surfaces of the boiler. As free and rapid circulation of the water in a boiler tends to increase its efficiency, care should be taken to so distribute the tubes and furnaces that the steam bubbles may have free and unobstructed access to the liberating surfaces.

* Abstract of committee report, H. L. Wratten, chairman.

In designing horizontal tubular and other types of externally-fired boilers, we find little difficulty in arranging the different parts to come in contact with the water in such manner as not to retard the natural flow of the uprising steam bubbles and cause imperfect circulation.

The internal-fired marine type, on account of its internal-furnace construction, presents many difficult problems as regards circulation which are hard to overcome. The principal causes for imperfect water circulation, we will assume, are the improper distribution of heat, the wrong application and temperature of the feed water, and probably, in some few cases, faulty design and construction. The design, however, will be harder to change than to remedy the exit of feed water and improper distribution of heat.

We find that a number of our internal-furnace marine boilers have the Morison corrugated or Adamson expansion-ring furnace. The grates are set about the center of the furnace and extend back from 7 to 8 feet, or about two-thirds the length of the furnace, and one-third of the furnace and the bottom of the boiler gets no benefit from the heated gases, the fire passing from the furnace to the back combustion chamber, through the tubes and into the stack at the front end of the boiler. This design, while it eliminates all the trouble of cracked walls and draft leaks, has so large a body of water under the grates that unless some means are used to start it moving along the currents of circulation, it not only retards the efficiency of the boiler but also tends to pit and corrode the shell; especially is this true where leaks develop in rivets or seam.

Many designers recommend the use of outside circulating pipes of different types. They assume that the water carried up with the steam will descend through these pipes and thus displace the water in the bottom of the boiler and move it along with the currents. If this were true it would be easy to find a remedy for the trouble, but it being a theory and not a fact we get little help from that source.

As regards the best place for the feed water to enter is a question that requires a great deal of thought, and while we believe that the proper place for feed water to enter a boiler is the part that is least affected by the heat, as the feed water entering will be, or should be, at least 180 degrees or 200 degrees F., it will either move the water from that part of the bottom, or by imparting some of its own heat through conduction will start it in a natural flow.

The report was accepted and opened for discussion.

Mr. James Crombie: With regard to the vertical boiler and the horizontal tubular boiler, the circulation is very nice, but with regard to the marine boiler you will find that sometimes twelve hours after the fire is started it is almost cold at the bottom and the temperature has not risen above 80 degrees. Now there is a device which does not require any holes in the boiler; it is attached to the braces and the water rises from here, the head of water that is involved in connection with it, but the difference of temperature causes the expansion of air inside this and compels the water entering here to eject from this pipe like the working of a pump. With this device it is found that for about two hours the temperature continues the same, then it rises about 200 degrees and keeps on doing that, and at the top of the boiler it has the best of it all the way up. I might say that the *Titanic*, the big ship that went down, the *Mauretania* and *Lusitania*, and all the large vessels, are fitted with that device for circulating water in the marine boiler. There are other devices for this purpose, considered some of the best and recognized as standards, giving excellent results.

Mr. Optenberg: All internally-fired boilers give very much better results with a Dutch oven; it throws the heat down lower and consequently has a tendency to heat the bottom of the boiler.

Mr. Conrath: Would it be possible, after the fire had passed through your furnace and come through the flue, for it to return again underneath the boiler and have it come out on the opposite end? That would keep a uniform temperature all over the boiler and would be a remedy if it could be done.

Mr. Optenberg: That can be done, providing, however, that the heat is not passing through the bottom of the shell at too high a temperature, for the reason that on large diameter boilers you require a very thick, heavy shell, and if the heat is too great it would be the same as an externally-fired boiler. The idea is all right to utilize the heat of the gases for assisting the circulation of the boilers.

THURSDAY MORNING SESSION

The association ratified the action of the executive board in passing favorably upon the fifty-four applications for membership received.

What Are the Advantages and Disadvantages of the Use of Brick Arches and Arch Pipes in Locomotive Fire Boxes?

(This report will be published in the July number.)

The report was accepted and opened for discussion.

Mr. A. N. Lucas: We have very little trouble with the brick arches in switch engines. I do not believe that the jarring that a switching engine does affects the arch. We find that our arches go to pieces faster in our heavy passenger engines making big mileage, due to the extreme heat necessary, which the switch engines do not get. Take our heavy freight engines; they don't make the big mileage, but they are in service and pulling tonnage, but we are getting very good service from the brick arch in all of our engines, between 1,800 and 1,900; we've got brick arches and arch tubes in them all.

Mr. Wells: In regard to the life of the fire-box being increased or decreased on account of the arch tubes, as you all know I have been an advocate for a good many years of the arch tube on account of the circulation it puts into a fire-box and the water in the fire-box. These answers here don't look good to me. "Fire-box life prolonged" only 5; shortened, 12; neutral, 14. Now in my opinion there isn't one thing about a locomotive boiler that increases the life of the side sheets so much as the arch tubes. I believe that if you will run your arch tubes about three-quarters of an inch through the sheet—I wouldn't object to an inch—and bell them out to about 45 degrees, you will never have any trouble with them. Be sure and keep them clean, and spend all the money that is necessary to keep them clean, and they will do more for you to protect your side sheets than anything else that I know of.

Mr. Ewell: My experience on the Boston & Maine in regard to arch tubes is this: About nine years ago the Boston & Maine got twenty or twenty-five of what we call the C-21 class engines; they had the arch pipes in them; they were taken out and four short pieces of tube put in the holes and a plug put on the outside sheet to keep the air out. I received instructions about four months ago to put a patch on the outside of the throat sheet to cover up those four holes, and four small patches on the inside to cover them up on the inside. I got as far as doing the job on one engine, and when I got to the next engine I received instructions to patch no more, as they were going to put the arch pipes back and use the brick arch.

Mr. J. S. German: I would like to call your attention to a few years' experience that I have had with brick arches, not only on the Lake Shore Road but other roads. I wish to call your attention to one road especially, where it was thought impossible to use arch pipes. Arch pipes on that same road, at the time I am speaking about, would only last thirty-four days before they would have to be renewed. They were taken out as they were delivered to that road thirty-four days afterwards, pieces cut off the arch tube, whole pieces rolled in and the outside plugged up. Our assistant superintendent of motive power said to me, "I want arch tubes used in those engines; they must be used." Well, that put me up against it; I didn't know how to keep them clean, and I was as bad as the rest of the boiler makers, I said they couldn't be used on that road. However, we hunted around and we got a tool that was on the market that I didn't know anything about, and the arch tubes were put back. Mr. John Carroll, the master mechanic on that road, equipped 120 engines in a year with arch tubes and bricks, and the arch tube, after we used the cyclone cleaner, we could run those engines for eighteen months without removing a flue. That year it cost that road $10,000 to equip the 120 engines with brick and flues, and comparing the mileage and the tonnage with the year before the company saved $50,000 in fuel. So much for arch pipes on that road. Now we've got on the Lake Shore 1,001 engines, and out of the 1,001 there are only six engines with very shallow fire-boxes that arch pipes and bricks are not used in, and I don't know that our men, being used to the arches on that road, experience any more trouble with cracked side sheets, leaky crown sheets or any other thing, than they do on these engines that we have got with no arch pipes. The only thing there is about an arch pipe, in my experience, is to keep it clean, and it will cause no trouble, but it will not stand any obstruction whatever, and, gentlemen, they can be kept clean and economy can be got in fuel. I am given to understand that right on the Lake Shore road to-day they are saving in fuel from 8 to 12 percent.

Now I know as well as all of you know, or a good many of you, anyhow, that the majority of boiler makers object to brick arches. I did myself when I was working in a roundhouse; I didn't want to go on an arch. But there is a brick on the market that is made in small units and can be very easily removed; a man don't have to get on them, and it's a good thing they don't have to get on them, because they can be removed, the center portion of them. A man on the hot work can get down and do his work, and in the meanwhile if there is any accumulation on the arch it can be very readily cleaned off, and an arch is like every other portion of a locomotive boiler—it wants taking care of.

Since last August, Mr. McBain, our superintendent of motive power, conceived the idea of putting an arch on our switch engines around about Cleveland to overcome the difficulties of black smoke, so he gave orders to put a full installation of bricks in a pony, which the blue print will show. It has eight bricks, close against the sheet all around, against the flue sheet, up against the door sheet, with the two top corner bricks, that is, 14 by 14, left out on the two top corners, and the third brick down or the sixth brick up, the three bricks in the center left out. Of course, when it was put in I didn't have any faith in it at first, but, gentlemen, I want to tell you, they haven't got better steaming engines for switch engines, and they burn their smoke, and the small particles of coal that are shoveled into a fire-box and would escape with an open arch don't escape now. Previous to this installation, in firing those engines, the small particles of coal would go through, so rapid was the exhaust that they wouldn't have time to burn consequently they would stick in a tarry substance to the netting and they would bake there; all the carbon would burn out of it and it would form a kind of a clinker. We don't have that to-day with those engines. While we have a little accumulation on the arches from time to time, we don't have it on the flues nor in the flues nor in the front end.

Mr. Gray: How long after an engine with a brick arch finishes its run before the boiler maker can get in the fire-box to work on the flues?

Mr. German: We have cases on the Lake Shore road. We dump all our passenger engines on arrival, every one of them, and our freight engines are dumped if leaking; if not, every seven days. Now, the passenger engines being dumped every trip, they have got a man in the roundhouse that goes into every one of them, whether they are leaking or not, and looks on top of the arch to see that there is no accumulation. I don't know exactly the time from the time they leave the cinder pit till they get to the roundhouse, but I should judge about twenty to twenty-five minutes after the fire is dropped. If the engine is leaking the brick man goes in there and removes the brick and the boiler maker goes in and does his work. I don't know that they could do it any quicker than that. Now we found, when we installed the brick at first, that we had to take the boiler makers off the bricks, not let them handle them, and we put men in our large roundhouses on that special work—moving bricks and cleaning them off—cleaning off what was not moved and blowing the flues out. Boiler makers would then go in and do their work and come out and the brick men would go back and replace the arches. Sometimes in removing the brick, after the arch was probably ten or twelve days old, they would be thin in the middle; that is, where the most friction takes place; the men might break one or two in pieces and they would be replaced with new brick, but there's never a full arch broken. There's always more or less left in the box, and the average life of our bricks on that road, on passenger engines, is thirty days, on freight engines forty-two days and on switch engines 144 days.

Mr. A. E. Brown: The question is hardly debatable as to the value of a brick arch in a locomotive. The greatest part, in my opinion, is the care taken of the arch. I believe that we have made a decided improvement in this particular part of a locomotive, and they are rendering better service and economizing fuel; there is also a betterment in the steaming qualities of the engine. While it may assist in the combustion of the gases, yet I would not want to claim that it would be a smoke consumer; there's no doubt but what it helps that evil. It has been said that these arch tubes are scale accumulators. The remedy for this is to keep the tubes clean.

Mr. A. R. Hodges: It was unanimously agreed at the last convention that the brick arch was a good thing, but little was known as to whether it was a paying proposition or not. I believe now, however, that it is absolutely a paying proposition, and that it will justify any railway company to inaugurate and apply the brick arches, because it is beneficial in every way.

Mr. McKeown: I have got a piece of a pretty heavy arch tube that has only been in a week, and I would like to know what causes them to bulge under the intense heat.

Mr. German: When the arch tube is kept absolutely clean, which can be done, you won't have this trouble.

Mr. C. P. Patrick: These tubes bag and pocket and blister without a particle of mud on them. The fire, shooting right up against the tube, drives the water away from this part of the tube, and a spot about the size of a large goose egg will become hot, and then the pressure on the inside will push it down and create the bagging, and I have seen it in watertube boilers.

Mr. M. W. Wilson: On the Rock Island Railroad we have been applying brick arches for about six months, and we have had considerable trouble with the arch tube. I am not going to say anything in regard to the arch itself, because I believe it will work for economy. We applied No. 10 gage 3-inch flues, and six days after applying they had to be removed on account of the bagging of the flue on the bottom. In taking the arch tubes out and making an examination of them we didn't find any scale in that particular engine where we removed the tubes in six days. In some of the engines where the tubes ran ten days or two weeks before removal, we found in the tubes a scale like an egg shell, which, in my opinion, was not heavy enough to cause the tube to bag. We did not find any accumulation of mud or scale banked up in the flue where the flue bagged. A little later we received No. 7 gage tubes, which is three-sixteenths thick, and we find that those tubes are running along from two weeks to four weeks without removal, and when we remove them it is on account of being bagged on the bottom, not because of the accumulation of scale or mud in the tube, but because, in my opinion, the bottom of the flue is not protected by water at all times. The circulation in the tube is either too rapid, or, which amounts to the same thing, the fire impinges too severely on the bottom of the flue, which causes it to bag. Some of the worst bags were 2 feet from the door sheet, where the fire comes around the arch. Our arches ran up within 18 or 24 inches of the crown sheet. The trouble occurs from the flue sheet to the door sheet.

Mr. O'Connor: We have some locomotives in which the arch pipes are very low and we find more trouble in the lower bed, because the arch tube, when the fire is a little heavy, is over the bed of the fire.

Mr. Wilson: In the engines I refer to the distance from the bottom of the tube to the grate at the flue sheet is about 20 inches, and at the back the tube is about 54 inches above the grate. Where the fire came over the back of the arch we soon had a great deal of trouble from leaking. The longitudinal seam in the fire-box and the crown bolts gave us continual trouble from leaking where the fire whipped over the back of the arch. Of course, that trouble possibly could be overcome by lowering the arch.

Mr. Optenberg: Unless you expand your tube evenly all around, be it straight or bent, you will find that you will create a greater amount of expansion on the part of the tube, which becomes natural on the arch tube, to be the lower side of it. The upper side is covered with your arch brick. Now, then, in that case the lighter your tube the less uneven expansion you have got to contend with. It is possible that if the upper surface of the arch tube was not covered by the arch brick so you could submerge your tube into a certain uniform temperature of gases all around, you would do away with your trouble entirely, but under the conditions that you are operating and using your arch tube, you can expect nothing else but that your tube will bag or, if imperfect, will blister, whether you have any scale or not. I want to predict this, that you will have more trouble with the straight-arch tubes than with those bent on a 9-foot radius, for the reason that the expansion must go somewhere, but you will never overcome the trouble as long as you cover one side of the tube with firebrick and leave the other exposed to the fire.

Mr. McKeown: The first tube we removed here had only been in about a week, and we didn't have any arch tube on hand to supply its place, so we took a 3-inch flue, which is 125 Master Mechanic's gage, and that flue is still running to-day at probably half the thickness of this tube and gave us no trouble, so it looks to me that the nearer you can get the water to the fire the better results you will have. We don't have any trouble with the arch tube leaking, just simply bagging in the fire.

Mr. D. A. Lucas: I have been in close connection for the last twenty-five years with brick arches and arch tubes, and I know there are districts in the country or in the United

States where you can use the arch tubes successfully and there are other districts where you cannot, and the conditions that exist are the cause. My theory is that the fire is confined with the brick arch, where the arch tube is used to support the brick arch, to such an extent that it boils the water, or the circulation is not rapid enough to keep the water in the tube, causing it to heat and bag. I have seen the same thing happen in watertube boilers. Where the boilers were forced excessively the tubes bulged and burnt; the heat was too intense for the circulation, but after the boilers were run at a normal rate the trouble was avoided. Now where you suspend the arch with the circulating tubes in a light water district you will have that trouble of bulging.

I think the brick arch, in itself, is a good thing in the right place. I am working for one of the roads that is about as strict on saving and as economical as any of them, and if the brick arch in a bituminous shallow fire-box was a benefit, I am satisfied they would be only too glad to use it, but by absolute proof we got no benefit from it in a shallow fire-box burning bituminous coal. In our lignite burner we use twelve arch bricks and find it a great success and a benefit.

Mr. Andrews: The Chicago, Milwaukee & St. Paul have been using arch brick and arch tubes for the last twenty-two years, and our standard is No. 10 gage, and we feel that we are getting first-class results. If they keep these tubes clean, examine them thoroughly, get the water through them, I think the No. 10 gage is about the proper thing. Some of the boilers built have a flat, crowfoot belly brace; a great many people shove them too close to the flue sheet; it's a good idea to move them back and give all the water space you can in the throat sheet and not congest it there; give the scale a chance to come down and get away; don't clog it up on the belly of your boiler; make your brace longer and your bolts longer and they will stand better.

Mr. J. L. Fagan: In discussing those things, no one said whether the brick arch was an oil-burning proposition or was for burning coal. We had to do away with the arch or do away with the crown sheet. We had trouble with the side sheets and seams, and did away with them, and got in its place the spatter wall next to the fire-door and have had no trouble since.

The discussion was closed and the committee discharged.

Election of Officers

The following were elected officers for the association for the ensuing year:

President—Mr. M. O'Connor.
First Vice-President—Mr. T. W. Lowe.
Second Vice-President—Mr. J. T. Johnson.
Third Vice-President—Mr. Andrew Greene.
Fourth Vice-President—Mr. D. A. Lucas.
Fifth Vice-President—Mr. John Tate.
Secretary—Mr. Harry Vought.
Treasurer—Mr. Frank Gray.

New Members of the Executive Committee—Mr. W. H. Laughridge, Mr. A. N. Lucas, Mr. B. F. Sarver.

FRIDAY MORNING SESSION

Best Method of Staying the Front Portion of Crown Sheet on Radial Top Boilers to Prevent Cracking of Flue Sheet in Top Flange*

The first radial top boilers built were all rigid and soon cracked all across top of back flue sheet. Then came the eye-bolts and sling stays, which did fairly well in good water, but as they grew older the eye-bolts broke off either at the bottom or top. Then in bad water the sling stay filled up with hard scale and became a rigid stay, and was no better than the original plan.

Next came the tee-bars with strap braces and oblong holes to take care of the upper movement; but as the back flue raised up in the center from continuous expanding of the flues, it likewise raised the tee-bar and put a twisting strain on the bars and buckled the sheet directly at both ends of the tee-bars, and later developed a crack lengthwise of the crown sheet between the last four bolts in tee-bar, and very hard to find unless a very close inspection is made from the inside. It cannot be detected from the fire-side of the sheet until it comes through, and it is too late to find it then, especially so if the engine is just out of back shop with general repairs.

Also, the space between the last strap brace on tee-bars and next radial stay-bolt is too great, and it is often necessary to put on an extra brace at point mentioned.

Also, the tee-bars take up too much valuable water space, and is a dam to catch mud and scale unless the closest kind of inspection is done through side holes on wagon top.

The next and latest method is the flexible stay-bolt. I have inquired from some of the leading railroads who have had them in service for some time, and they have reported that the crown sheet was perfectly straight and top flange of back flue sheet as perfect as when new, and I believe it the best plan.

Flexible connections to fire-box assemblage in late years have been reorganized as essential to overcome a too rigid construction, and the flexible stay-bolt has served the means quite satisfactorily, and is particularly adapted for crown stays, especially in the six rows back of flue sheet, where its serviceability is acknowledged, not only for its merit as a stay, but more largely on its value as a medium to prevent flue sheet flange bending and cracking.

In evidence of the true merit of this plan of staying the front portion of the crown sheets in radial top boilers to prevent cracking of flue sheet in top flange, I find that not only large railroads are adopting and using it, but likewise the locomotive builder is fast recognizing its merits and the same is being used to quite a large extent over other old methods.

The question may arise, is there a possibility of the crown sheet raising up so much that the bolt will hit the cap and make cap leak under jacket? But as far as I can find out this trouble has not developed; but if it did it could easily be adjusted at each shopping or inspection when caps are removed.

J. W. Kelly.

It is not considered that the staying of the front portion of the crown sheets has any relation to cracks which develop circumferentially at the root of the top flange of the back tube sheet, or with those extending upwards from the top tube holes, because each of the following designs of staying has been in general practice without effecting a remedy, *i. e.*, radial, screwed stays, flexible bolts, stirrup forgings to the roof sheet with an unturnable nut in the stirrup, eye-bolts and sling stays and tee-bars with strap braces; and although some of the designs are superior to others as a stay, none of them has been responsible for eliminating the cracks. The results of my experience favor flexible bolts and stirrup forging as suitable stays for the location, and they are recommended because they are as flexible as bolts under tension can be, have fewer parts to maintain and inspect, do not interfere with circulation, and are not a receptacle for foreign matter, but they are not recommended to prevent the tube sheet cracks, although it is generally thought they have some latent influence in preventing them.

My contention is that the circumferential cracking in the top root of the back tube sheets is due to the same cause as that which produces like cracks circumferentially in the heel of the front tube sheet. My opinion is that 3 inches is about a proper radius for tube sheet flanges, and the edge of the tube

* Abstract of committee report, J. W. Kelly, chairman.

holes should never be closer to the root of the flange than 4 inches, so that when this condition exists, assisted by good treatment, the back tube sheets will be worn out in the body in advance of the top flange cracking circumferentially, regardless of what design of stays are applied at and near the front end of the crown sheet.

The causes for cracks extending upwards from the top tube holes and around the flange of the back tube sheet are: Boiler pressure tending to crush the flange, expansion and contraction of the tube sheet body, a rigid crown sheet and side sheets united to the flange of the tube sheet by riveting, and secured to an outside fire-box with stay-bolts, thus preventing the tube sheet altering its shape, and the surging of the water during the application of the air brakes.

Remedies are suggested for these troubles, also the questions of cause of flue holes in back flue sheet, elongating and a preventive for same, and the effect of the use of combustion chamber are discussed in this report. T. W. LOWE.

The report was accepted and the committee discharged.

Superheating of Steam and its Relation to the Upkeep of Locomotive Boilers*

There are many designs of superheaters now in general use in the United States and Canada, but the Canadian Pacific Railway have fully demonstrated their faith in the Vaughan Horsey design, by applying to it all the new engines and rebuilds, until at this time there are over 900 equipped and successfully operating, even more economically than was at first anticipated.

The common upright and submerged flue boilers have self-contained superheating as part of the boiler; again, superheating can be separated from the boiler by using an extra furnace, and, again, it can be arranged independent of the boiler to take up a portion of the heat from the escaping gases before they reach the atmosphere, and, finally, another arrangement is to give up a portion of the boiler-heating surface to accommodate the superheating pipes, and it is this last-named variety with which we are most concerned, as it is more related to the up-keep of the locomotive boiler than other designs, because it is necessary to apply a complement of 5-inch or larger flues in the boiler, in which to locate the superheating pipes. With this design the large holes in the front tube sheet are generally drilled about ¼-inch greater diameter than the body of the flue, the flue being swelled hot to fit that end before application, thus economizing on the labor attached to removals.

The large holes in the back tube sheet are drilled smaller than the main flue, and the latter are swedged several inches back, thus providing an abundance of water space at the fire-box end, as well as ample material between the tubes, to prevent cracking of the interstices during the setting and maintaining of the flues. No copper ferrules are used to surround these large flues in the back tube sheets, and they are either welded in place or rolled to a joint by using four rollers in the tube expanders, then lapping and beading both ends of the flues with a suitable sized beading tool to take care of the thicker flue.

These large flues are handled in the shops under the same general methods that are followed with smaller flues, the safe ends are welded with a proportionately heavier roller tube welder, and the fire-box end of the flue is swedged with a hydraulic push swedging machine or suitable top and bottom die. During six years' experience we have had no weld failures, and are practically free from leakage in service because of reasonable attention, such as stopping all leaks after the fire is drawn, whether reported leaking on arrival at the terminal or not, and by blowing out all cinders with air.

The working steam pressure on superheated engines is generally 180 to 200 pounds, and those on light power 160 pounds. The same sized engines and boilers under the two former pressures, operating in good and bad water, have not yet shown any marked difference in cost of boiler maintenance, and unless there is a saving in machinery expense with the low-pressure there does not appear to be any good reason why the 200-pound pressure engine is not better and more powerful than the 180 pounds.

Superheating has not reduced the mileage run between washouts, and although the fire-box space is found in better condition we cannot accurately compare the quantity of scale and mud collecting between set washout mileage in superheating engine boilers, yet we are satisfied there is a better all-round condition and decreased foaming of the boilers in service results.

Competent authorities state that there is a saving in fuel averaging between 10 to 25 percent in favor of superheating, the fluctuations during the tests being due to conditions. This is also accompanied with a correspondingly decreased consumption of water and a longer life between flue and fire-box plates. Superheating does not increase the boiler pressure, but superheated locomotives are competent to handle tonnage in excess of those using saturated steam.

Ordinarily there is about 21 to 29 percent of tube heating surface sacrificed in a locomotive boiler to substitute about 14 to 17 percent of superheating pipe surface, and the ratio of tube heating surface to superheating pipe surface is about five to one, and, although this might appear to be a loss from a boiler point of view, it is not so, because results show pronounced savings in fuel and water, accompanied with a decreased number of flues to apply and maintain.

During the severe frosty weather in Northwestern Canada the superheated engines develop less flue and boiler failures compared to former saturated steam engines, which of itself is an economy not to be overlooked. My entire experience with superheating of steam has been confined to one design, but if all the other varieties are as closely related to the upkeep of the locomotive boiler as this design is the railways need have no fear of losing their patronage because of delayed trains; neither will the management lose their reputation by installing the device, because of the many economical advantages it imparts to the boiler and engine.

The Chairman: Mr. Lowe says here in his report that the flue is best applied in the back end without copper ferrule. In the road I was connected with we used a copper ferrule in the back end and also a sectional expander with twelve sections to the set, the flues and the roller—we had five small rollers—and if these flues could be maintained in service and give good results without copper ferrules, it seems almost useless to go to the extra expense of buying copper ferrules. I might also say that the standard superheating tubes adopted by the superheating company, which controls most of the superheaters, is 5⅜ and 5½ inches on the outside, and both sizes reduced to 4½ inches in the back end. From talks I have had with road foremen of engines it seems when you have a big train and are working the engine hard that you get as high as 750 degrees of heat at the steam chest, and that, with a boiler 200 pounds pressure, would be 388 degrees of heat in the boiler, and you get that extra heat due to the superheater; that is, when you are running an engine with an open throttle and cut-off, that retains the steam in the superheated unit longer than if you had a closed throttle and just left enough steam in for what you want to use. The advantage of having an open throttle is that you can have the superheater pipe full of steam all the time and have the advantage of the steam passing through there slowly and get all the superheat you possibly can out of the heat passing through the superheating

* Abstract of committee report, T. W. Lowe, chairman.

tubes. Some engineer will say that you can't stall them; that is, they pull more. Starting a train is exactly the same as it is with a saturated steam engine, because if you are carrying 200 pounds of steam you are only getting 200 pounds pressure on each square inch of your piston, but the advantage of superheating steam is that it eliminates the saturation and the steam works expansively, and you don't need so much steam as when you are using saturated steam, which they brought out in their report very nicely.

Now, on a road which I was formerly connected with, an engineer had a device whereby the water was put into the engine at boiling heat; in fact, it got up sometimes as high as 225 degrees of heat going into the boiler. The system consisted of exhaust steam passing through a pipe alongside of the engine and back to the tank and going around coils of pipe, and inside the pipe was the water, which would be pumped into boiler and got the heat from the exhaust steam. Tests on that system of superheating showed a saving of fuel and also a saving of flues, and on one engine to which it was applied there was hardly any work for a couple of years. I don't think the flues were expanded but a few times, while on other types of engines running in the same district the flues had to be expanded quite frequently, which shows that the injecting or putting water into the boiler over the boiling point is a considerable saving in fuel and in the up-keep of a locomotive.

Mr. G. E. Ryder, a representative of the Locomotive Superheater Company, New York, gave a detailed description of the type of superheater which this company manufactures, together with its advantages, as compared with other types. A paper covering in substance Mr. Ryder's remarks is given in full on page 178.

The Chairman: The standard practice, according to Mr. Lowe's report, is that they apply these superheater tubes without copper ferrules; have they applied any with copper ferrules so as to note the difference?

Mr. Lowe: We have not used copper, although it has been tried on one engine, due to an error or having stock of a size which was smaller, and we made that up with the ferrule, but we find that we don't need the copper ferrule; we find that we get good results whether the water is good or bad. There are some cases where we would not have to calk the flue in a year or two years, and in other cases we might have to give them attention now again after they had been in service for some time, but we are practically free from trouble with reference to leaking in service.

Mr. Ryder: I know of some engines in the States that are running without copper ferrules and have not given trouble, and I know of some that are running with copper ferrules and are giving trouble; but the bulk of our experience points toward the use of copper ferrules and a little heavier copper ferrule than is used with the small flues.

The use of superheated steam is responsible for a decrease in the boiler maintenance cost; it makes it possible to reduce the boiler pressure without affecting the smartness of the engine, because larger cylinders can be used, since the condensing surface requires no consideration. A further reduction in boiler cost is obtained because the flue maintenance cost is lower in severe conditions. There is one more point; the superheater engine will develop the same power on 35 percent less water, and you should be able to lengthen the periods or increase the mileage between washouts if your engines are developing the same power in proportion to the water you save, and that has been the experience in some cases that I know of.

Mr. Gray: We have engines with 29-inch cylinders and 62-inch drivers, carrying 160 pounds of steam pressure. I guess that is as low as anyone using superheated engines. There is one thing I have noticed about them; once in a while one of those engines will come in with all the large flues leaking, or possibly two rows of them, sometimes the whole set, and no small ones leaking. In every case we have tested the engine, and found the superheater practically leaking at one end, and we have never found any of those large flues leaking unless there was a leak in the front end. Sometimes there will be three or four or five simmering a little bit when the small flues are leaking, but when we found the large flues leaking and no small ones, or only a few, we've always got a leak in the front end.

Mr. Ewell: He didn't say whether the fire-box end was the large or small end.

Mr. Ryder: The small end. We have 24 inches between the flue sheet and the back end of the superheated coil or unit, as we call it; we have 18 inches from the small portion of the flue to the end of the superheater unit, so you can apply about 18 inches of safe-end before you are in any danger of coming in contact with the unit.

A Member: What end would you suggest to safe-end?

Mr. Ryder: The small end, the fire-box end, because the material in the fire-box end is subjected to the most severe part of the flue and you are supplying new material where the conditions are severest. Another reason is that the small end of the tube is smaller in diameter, of course, and the cost of safe-ending material is less. The third reason is that the 4½-inch diameter is standard, and it is only necessary to carry one size of safe-end for both 5⅜ and 5½-inch flues.

Mr. Lowe: We are not following the practice on Western lines of welding the safe-end onto the 5-inch flues at the fire-box end. We have reversed our practice in the case of the 5-inch flues, and we have been using those flues since about 1905, and we have had no bad results whatever from welding on to the smoke-box end. By doing so with the machinery that we have we save one operation.

Mr. Goodwin: Do you get any more mileage out of a superheated tube than out of your small tube?

Mr. Lowe: Yes.

Mr. Goodwin: You don't have to remove the superheated tube every time?

Mr. Lowe: Not every time.

Mr. Goodwin: Do you get two settings out of your superheated tube?

Mr. Lowe: Frequently. Mr. Ryder mentioned about different sized beading tools. We have two size beading tools only: that is, a No. 1 and a No. 2. We used to carry the different sized beading tools, and we came to this conclusion, that if it was right to put in a tube with a standard sized beading tool that was the size to maintain it under, and when it grew to be too big we made it the right size for the tool. Therefore we carry a beading tool to suit the 2 and 2¼-tube and another to suit the larger tube, which necessarily is a much larger tool.

Mr. Hennessy: How do you save the company money by welding on to the front end and using the back end of the flue by heating and upsetting? Does that retain the life of that material by heating and upsetting? Suppose that flue is a little thin, you are supposed to have a No. 7 gage in there. That flue is reduced down to No. 12, No. 13 or No. 14 gage; how are you going to upset that back far enough in there to retain the strength of that flue? If such is the case, saving the company money, why do you buy this new material for safe-ending? Why don't you use your old tube, if you can handle that that way? By not using copper ferrules, Mr. Lowe says they run their flues from a year to two years without leakage. That is something remarkable. We can't run our flues that many weeks without leakage, and we use copper ferrules, 13 and 15-wire gage. I believe, in welding and safe-ending flues, the proper place is in the back end to put your new material.

Mr. Greene: I think the proper place to weld a superheater tube is on the front end; that is, the first weld; then the second application of the tube weld on the back end, and by doing that you get away from a weld every other time you apply the flue.

Mr. Robert Brown: I would like to have a word to say in reference in regard to handling the tube and maintaining the 5-inch tubes without the copper ferrule. I have been handling those tubes for the last five years on superheater engines, and we have never had any difficulty at all in keeping the live tubes tight without the copper ferrule, and in my country, where we have pretty good water, we get always two settings on our large tubes. What I mean by that is, we install two sets of the small tubes to one set of the large tubes, and I have also handled them in bad-water districts and we get the same results. We have never installed any copper in my time for the last five years, and have always got good results.

Mr. Optenberg: As to the proper place to put the weld, and whether or not to use copper as a ferrule in setting the tube, my experience is this: in all cases where opportunity permits us to do away with the copper and set the flues direct with the same nature of material that gives the best results. In placing a weld on the tube I always instruct my men to put the weld where the gases are the coolest, because we cannot expect, even with a new end, to obtain the strength of the solid flue if the flue is in any kind of condition.

Mr. O'Connor: Fifteen years ago I tried an experiment on an engine, putting in tubes half with copper ferrules and the other half without the ferrules. This was on the Chicago & Northwestern, west of the Missouri River. In five weeks it was necessary to remove the flues without the copper ferrule, we couldn't make them tight; we tried every method we could and finally removed them, and the flues with the copper ferrules on ran twenty-one months without being removed.

The Chairman: In connection with Mr. Lowe's report, the Canadian Pacific Railroad are pioneers in the use of superheater engines. They were using them over there long before they were adopted in this country, and in the country Mr. Lowe came from the climate is severe and the water is bad, and if they can run suprehater flues up there without copper ferrules I think they can do it in most parts of the United States.

Mr. Carter: Regarding the damper in the front end of the superheater, has anyone had satisfaction with taking out this damper and eliminating it entirely? We have the damper, which is closed only when the throttle is open, but some of them tell us they use it without a damper.

Mr. Lowe: It depends largely on the territory that the engines are working in. There is danger in a mountain section, where you are running shut off down the grades for a considerable length of time; there is a danger when you open up that there might be some condensation laying in the pipe that would fly and cause some injury to the header, but on the regular grades, at least the regular grade along the level road, we have no trouble without the damper.

The Chairman: I understand that the use of the damper is this: when you are not using the engine to close it, that prevents the heat passing through the superheater flues and heating up the superheater unit, and lets the heat pass through the smaller tubes. That's the advantage of the damper, in my opinion. I think a damper is a good thing on there when the engine is standing still.

The discussion was closed and the committee discharged with thanks.

What are the Advantages or Disadvantages of Using Oxy-Acetylene Process of Making Repairs to Boilers?

Mr. Lucas: I have had the oxy-acetylene process two years, and I claim that it is in its infancy and hasn't got a good start, and there is a new field opened up every day for it and its limits are unknown.

The Chairman: No doubt the oxy-acetylene process of welding works more rapidly than the electrical welding process; the electrical process has its field and the oxy-acetylene process has its field to work in, that is my idea. The oxy-acetylene process will do the work quicker than the electrical, but where a sheet is to be patched or something of that kind, the electrical process doesn't heat the sheet so much as the oxy-acetylene does, and when it cools off it don't tear apart. I think the members will agree with me that each process has its place. I have seen some very good work done with the electrical welding process. Electrical welding don't heat the sheet, as I said before, on each side, and when it is cooling off it don't tear apart. With the oxy-acetylene process you may think you have made a good job and in a few weeks it will tear in the weld.

Another thing about electrical welding, whatever you are welding acts as a magnet; you can cut a piece out of the bottom of the mud-ring and weld right up overhead. That is the advantage of electrical welding; in fact, it is an important point that should not be overlooked, on account of the trouble we are having with cracked mud-rings. It would not be practical to turn the engine upside down to mend a crack in the mud-ring, but with the electrical welding process you can mend it and make a very good job.

It was voted that this subject be continued and the subject of electrical welding be added.

Time and Place of Next Meeting

The executive committee met and elected J. A. Doarnberger as chairman, and, in conjunction with the officers of the Supply Men's Association, they selected Chicago, Ill., as the next place for the convention, probably at the Hotel Sherman, some time in the month of May, 1913.

Boiler Flues

Mr. Optenberg: From what I have experienced in welding flues it really doesn't make any difference whether you weld an iron end to a steel tube or a steel tube to an iron end. We know that in welding steel to iron we must always adapt the heat; that is, accommodate the heat to the nature of that material, ignoring the iron, allowing a higher temperature, but as far as the strength of the weld is concerned I have made a pulling test of it and it's the same. The welding process is a little in favor of an iron tube, because you have got a trifle higher heat, and the tensile strength between the weld in all iron is a little higher than it would be on iron and steel.

Mr. Conrath: I would like to ask if you will please state what was the strength of the different welds where you were pulling iron and where you were pulling steel—the number of thousand pounds?

Mr. Lucas: We just had a test made of twelve pieces, welded twelve pieces of steel and iron together, a foot each, and had them pulled, and that the tensile strength ran practically the same; they pulled all the way from 32,000 to 36,000, and as high as 42,000 pounds, and the breakage was about an even break in the steel against the iron.

The Chairman: There's practically no difference between the pulling strength of the steel and of the iron. If there's no further discussion on that question we will close.

Report of Committee on Topics for the Next Convention

The following topics were submitted for consideration at the next convention:

1. How many expansion stays in a crown sheet would show the most efficient service?

2. Is there any limit to the length of tubes in locomotive

boilers without support in the boiler, and will the supporting plate impair the circulation?

3. When is a boiler in a weak and unsafe condition?

4. Best methods of welding superheater flues and tools used for same.

5. What effect do superheaters have on the life of fire-box and flues?

6. What advantage or disadvantage is there in using either the oxy-acetylene or the electric process for boiler-making repairs?

7. The best method of applying and the best method of caring for flues while engines are on the road and in terminal.

8. Steel versus iron tubes: what advantages and success in welding them and effect on mileage.

9. Effect of uneven temperatures: their causes and prevention.

10. What benefit has been derived from treating feed water for locomotive boilers, chemically or otherwise?

11. The proper inspection of a boiler while in service.

The following attended the convention:

M. Billington, F. M. B., B. F. & P., E. Salamanca, N. Y.
H. L. Paulus, Baird Mach'y Co., Pittsburg, Pa.
John P. Neff, Asst. to President, American Arch Co., New York.
Jas. E. Barry, Colonial Steel Co., Pittsburg, Pa.
Mrs. Jas. E. Barry, Pittsburg, Pa.
F. W. Renshaw, President, Kirby Equip't Co., Chicago, Ill.
G. J. Thust, Supt., Kirby Equipm't Co., Chicago, Ill.
A. C. Andresen, Asst. Gen. Dist. Mgr., Chicago Pneumatic Tool Co., Chicago, Ill.
R. V. Anderson, F. B. M., Am. Loco. Co., Schenectady, N. Y.
Mrs. R. V. Anderson, Schenectady, N. Y.
F. G. Harrison, Massilon Fdry. & Mach. Co., Massilon, Ohio.
A. M. Andresen, Chicago, Pneumatic Tool Co., Pittsburg, Pa.
Mrs. A. M. Andresen, Pittsburg, Pa.
Harry Alaman, F. B. M., Vandalia R. R., Terre Haute, Ind.
J. A. Albrecht, F. B. M., L. S. & M. S. Ry., West Seneca, N. Y.
Tom Aldcorn, Vice-Pres., Chicago Pneumatic Tool Co., New York.
John H. Allen, East'n Mgr., Scully S. & I. Co., New York.
W. B. Atkinson, F. B. M., M. & N. O. R. R., Eureka Springs, Ark.
Mrs. W. B. Atkinson, Eureka Springs, Ark.
Geo. Austen, Gen. B. I., F. T. & S. F., Topeka, Kans.
Mrs. Geo. Austen, Topeka, Kans.
F. A. Batchman, F. B. M., N. Y. Central, Elkhart, Ind.
Geo. Beland, F. B. M., Erie R. R., Hornell.
M. C. Beymer, Resident Sales Mgr., Am. Arch Co., Chicago, Ill.
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Mrs. C. Bader, Detroit, Mich.
John Barnes, Supt. Eng., Bird-Archer Co., New York.
W. H. S. Bateman, East'n Rep., Champion Rivet Co.; Parkesburg Iron Co., Philadelphia, Pa.
Mrs. W. H. S. Bateman, Philadelphia, Pa.
F. Baunin, F. B. M., Big Four, Champaign, Ill.
Mrs. F. Baunin, Champaign, Ill.
James Bruer, F. B. M., Frisco, Kansas City.
C. J. Bauman, F. B. M., N. Y. N. H. & H., New Haven, Conn.
Mrs. C. J. Bauman, New Haven, Conn.
J. F. Beck, F. B. M., G. R. I., Grand Rapids, Mich.
Mrs. J. F. Beck, Grand Rapids, Mich.
Miss Octavia Beck, Grand Rapids, Mich.
Miss Carrie Beck, Grand Rapids, Mich.
G. Bennett, F. B. M., P. R. R., Verona, Pa.
Mrs. J. Bennett, Verona, Pa.
G. W. Bennett, Dist. of Loco. Boiler I., Interstate Com. Coms., 131 Quail St.
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Arthur E. Brown, Gen. F. B. M., L. & N. R. R., New Albany, Ind.
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Mrs. Robt. Brown, Crandall, B. C.
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Mrs. Wm. George, Michigan City, Ind.
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Chas. Humpton, Parkesburg Iron Co., Parkesburg, Pa.
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John Harthill, F. B. M., L. S. & M. S. R. R., Cleveland, Ohio.
G. S. Hewitt, F. B. M., N. & W., Portsmouth, Ohio.
Chas. L. Hempel, F. B. M., U. P. R. R., Omaha, Neb.
Mrs. C. L. Hempel, Omaha, Neb.
E. J. Hennessy, F. B. M., N. Y. C. & H. R. R., DePew, N. Y.
J. E. Hennesy, F. B. M., N. Y. C. & H. R. R., Dewitt, N. Y.
Mrs. J. E. Hennesy, Dewitt, N. Y.
A. R. Hodges, G. F. B. M., A. T. & S. F. Ry., Topeka, Kan.
W. H. Hopp, F. B. M., C. M. & St. P. Ry., Dubuque, Iowa.
Mrs. W. H. Hopp, Dubuque, Iowa.
A. Hedderg, F. B. M., C. & N. W., Winona, Minn.
J. Handley, F. B. M., Terminal R. R. Assn., St. Louis, Mo.
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J. C. Keefe, F. B. M., H. & C., Bucyrus, Ohio.
R. F. Kilpatrick, Ewald Iron Co., Louisville, Ky.
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Locomotive Boiler Inspection

Under the new regulations of the Inter-State Commerce Commission, which went into effect July 1, 1911, all locomotive boilers are required to be inspected and reported every month, and the interior and exterior shell, braces, stays, bolts and seams to be inspected and reported each year. These reports are to be forwarded to Washington. The inspections are to be made with a hydrostatic pressure of 25 percent above the working steam pressure of the boiler. A specification card, including the general dimensions and stresses in the most important members of each boiler, is required.

In the calculation of these stresses, Mr. W. H. Burleigh, in *Power* for Oct. 24, presents the formulæ and tables in use by a Western railroad by the use of which it becomes a comparatively simple process to fill out the required card for any locomotive boiler.

Table I. shows the area supported by stay-bolts, crown stays and crown-bar rivets for various longitudinal and transverse pitch, while Table II. gives the diameter of the bolts and the areas at the root of the threads, minus the area of the tell-tale hole, which is 3/16 inch in diameter by 1¼ inches deep, and is drilled from the outside in all short stay-bolts. This gives the area at the smallest section of the bolt, and is calculated using the sharp V-thread.

The following notation is used in connection with the formulæ:

P = boiler pressure in pounds per square inch.
S = stress in pounds per square inch.
S' = shearing stress on rivets in pounds per square inch.
T = tensile strength of plate in pounds per square inch.
T' = tension in plate seam of lowest efficiency.
D = diameter of boiler in inches.
J = area in square inches supported by longitudinal stay-rods.
A = area of longitudinal stay-rod or gusset plate in square inches.
E = lowest efficiency of longitudinal seam.
Ep = efficiency of plate.
Er = efficiency of rivets.
Epr = efficiency of plate and rivets.
F = factor of safety = 4.
a = area of rivet hole in square inches.
a' = area of root of thread in square inches.
c = area of tell-tale hole in square inches.
h = pitch of stays, longitudinal axis of boiler.
i = pitch of stays, transverse axis of boiler.
p' = pitch of rivets.
p = pitch of outer row of rivets.
t = thickness of plate.

TABLE 1.—AREA SUPPORTED BY STAYBOLT

PITCH OF STAYBOLTS, INCHES.	PITCH OF STAYBOLTS, INCHES.																
	3½	3 9/16	3⅝	3 11/15	3¾	3 13/16	3⅞	3 15/16	4	4 1/16	4⅛	4 7/16	4¼	4 5/16	4⅜	4 7/16	4½
3 1/2	12.3																
3 9/16	12.5	12.7															
3 5/8	12.7	12.9	13.1														
3 11/16	12.9	13.1	13.3	13.5													
3 3/4	13.1	13.4	13.6	13.8	14.0												
3 13/16	13.3	13.6	13.8	14.0	14.3	14.5											
3 7/8	13.6	13.8	14.0	14.3	14.5	14.8	15.0										
3 15/16	13.8	14.0	14.3	14.5	14.8	15.0	15.3	15.5									
4	14.0	14.3	14.5	14.8	15.0	15.3	15.5	15.8	16.0								
4 1/16	14.2	14.5	14.7	15.0	15.2	15.5	15.7	16.0	16.3	16.5							
4 1/8	14.4	14.7	14.9	15.2	15.5	15.7	16.0	16.2	16.5	16.7	17.0						
4 3/16	14.7	14.9	15.2	15.4	15.7	16.0	16.2	16.5	16.8	17.0	17.2	17.5					
4 1/4	14.9	15.1	15.4	15.7	15.9	16.2	16.5	16.7	17.0	17.3	17.5	17.7	18.1				
4 5/16	15.1	15.4	15.6	15.9	16.2	16.4	16.7	17.0	17.3	17.5	17.8	18.0	18.3	18.6			
4 3/8	15.3	15.6	15.9	16.1	16.4	16.7	16.9	17.2	17.5	17.8	18.0	18.3	18.6	18.9	19.1		
4 7/16	15.5	15.8	16.1	16.4	16.6	16.9	17.2	17.5	17.8	18.0	18.3	18.6	18.8	19.1	19.4	19.6	
4 1/2	15.7	16.0	16.3	16.6	16.9	17.2	17.4	17.7	18.0	8.3	18.6	18.8	19.1	19.4	19.7	20.0	20.3

d = diameter of rivet hole in inches.
n = number of rivets in half the joint.

To bring a boiler within the required limits of safety, it is necessary to determine the maximum pressure at which the boiler can be safely worked. The law requires that on and after Jan. 1, 1912, the lowest factor of safety allowed will be 4. Then in the following formula F equals 4 and

$$P = \frac{T \times t \times E}{\frac{D \times F}{2}} \qquad (1)$$

The value E may be determined by analyzing the longitudinal joint for failure in various ways. In a double or triple-riveted butt joint the joint may fail by one of three ways: First, a tearing of the plate along the outer row of rivets; this section of the plate, minus the diameter of the rivet holes as compared with the whole section of the plate, gives the efficiency, or

$$Ep = \frac{p - d}{p} \qquad (2)$$

Second, it may fail by shearing all the rivets in the joint,

$$Er = \frac{anS^1}{ptT} \qquad (3)$$

Third, by a tearing of the plate along some inner row of rivets and a shear of one or more rivets in the outer row, in which case

$$Epr = \frac{(p - nd)\, tT + anS}{ptT} \qquad (4)$$

The lowest of these efficiencies is taken as the representative strength of the joint when compared with the whole section of the plate. Some of the seams are welded for a short distance at both ends, but this is not considered in determining the efficiency of joints.

In double and quadruple-riveted lap joints, or in fact any lap joints, there are two methods of failure considered, that of tearing of the plate and the shearing of the rivets, and the efficiencies are found by using formulæ 2 and 3. In applying the formulæ to the lap joint, however, the total number of rivets across the joint is considered.

A joint that presents a high efficiency is the Vauclain joint. Here the pitch is taken as the distance between the inner rows of rivets of two girth seams, and the efficiencies are calculated by the same methods and formulæ as are used for double and triple-riveted butt joints.

The maximum stress to which a stay-bolt is subjected at the root of the thread is given as

$$S = \frac{P \times h \times i}{a' - c} \qquad (5)$$

The quantities $h \times i$ and $a' - c$ can be taken direct from the tables and thus save much mathematical work.

In calculating the stresses in the longitudinal stay-rods, the area supported is taken as the segment of a circle, the arc of which is about 3 inches from the shell and the chord 2½ inches from the top of the uppermost row of flues. By measuring the rise of this segment and the length of the chord, the total area can be computed from the table of areas of segments found in "Kent's Handbook." The areas of all the rods are added together, and the pressure multiplied by the area of the segment, divided by the total area of the rods will give the stress per square inch in the rods; or the stress in longitudinal stay-rods or gusset plate braces, expressed by formula, is

$$S = \frac{P \times J}{A} \qquad (6)$$

TABLE 2.—AREA OF STAYBOLT, ROOT OF THREAD, LESS TELLTALE HOLE.

DIAMETER INCHES.	Decimal Equivalent, Inches.	Area, Inches.	Diameter at Root of Thread, Inches.	Area at Root of Thread, Inches.	Area at Root of Thread, Less Telltale Hole Inches.
3/4	0.75	0.44179	0.6057	0.2881	0.2605
25/32	0.78125	0.47937	0.63695	0.3186	0.291
13/16	0.8125	0.51849	0.6682	0.3506	0.3230
27/32	0.84375	0.55914	0.69945	0.3842	0.3566
7/8	0.875	0.60132	0.7307	0.4193	0.3917
29/32	0.90625	0.64504	0.76195	0.4559	0.4283
15/16	0.9375	0.69029	0.7932	0.4941	0.4665
31/32	0.96875	0.73708	0.82445	0.5338	0.5062
1	1.0000	0.7854	0.8557	0.5751	0.5475
1 1/8	1.125	0.9940	0.88695	0.6178	0.5902
1 1/32	1.03125	0.83527	0.9182	0.6622	0.6346
1 1/16	1.0625	0.8866	0.94945	0.7079	0.6803
1 3/32	1.09375	0.93957	0.9807	0.7554	0.7278
1 5/32	1.15625	1.05025	1.01195	0.80428	0.7766
1 3/16	1.1875	1.1075	1.0432	0.8547	0.8271
1 7/32	1.21875	1.16659	1.07445	0.90669	0.87909
1 1/4	1.25	1.2272	1.1057	0.9602	0.9326
1 9/32	1.28125	1.2893	1.13695	1.0152	0.9856
1 5/16	1.3125	1.353	1.1682	1.0718	1.0442

(3/16-inch telltale hole... 0.0276 square inch area.)

The area A is taken as the sum of the areas of the rods, or the least section of the plate, in plate braces generally through the angle fastening to the heads where the diameter of the rivet holes are taken from the whole section of the plate.

The Inter-State Commerce Commission allows double shear to be taken as twice that of single shear; hence for a longitudinal seam,

$$S' = \frac{P \times D \times p}{2 \times n \times a} \qquad (7)$$

where n is the total number of rivets in single shear, including each rivet in double shear being considered as two in single shear.

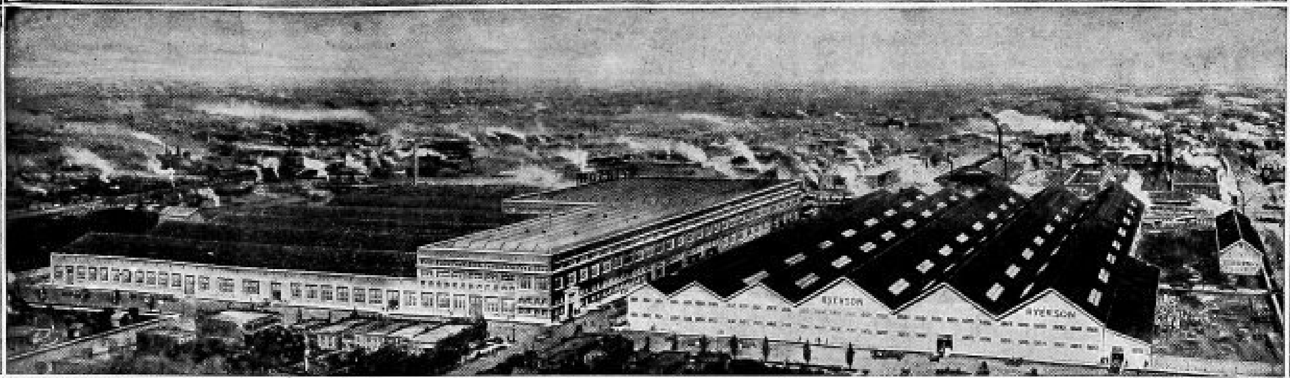
The quantity which in the majority of cases determines the factor of safety of the boiler is the tension in the plate seam of lowest efficiency, and is calculated as follows:

$$T' = \frac{P \times D}{2 \times t \times E} \qquad (8)$$

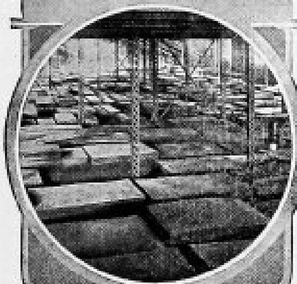
where E is the lowest efficiency of the plate or rivets as compared with the solid plate. From this the factor of safety is found by dividing the minimum tensile strength of the plate by the tension in the plate, as found in formula (8).—*The Engineering Magazine.*

The Riter-Conley Manufacturing Company has recently sold the buildings and grounds of its Allegheny shops on the North Side, Pittsburg, and will build a new structural steel plant of increased capacity at Leetsdale, Pa., where for a number of years it has operated a large plant turning out heavy plate work. Some of the machinery used in the old plant will be transferred to the new plant at Leetsdale, but a large modern equipment will be added. The capacity of the new plant will be 60,000 tons per year of fabricated material of all kinds.

Title has been taken recently by the Quaker City Iron Works, Philadelphia, Pa., to an additional plot of ground, 133 feet on Edgemont street by 102 feet 6 inches in the rear of their present property, also a side plot of ground having 15 feet frontage on Tioga street and extending back 358 feet. This addition about doubles the size of their plant, giving them an acre of ground in the heart of one of the best manufacturing districts in the city for the expansion of their business. The Quaker City Iron Works manufacture boilers, tanks, smokestacks, breechings and a variety of riveted plate metal work.

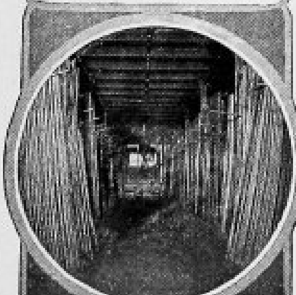


EVERYTHING IN IRON AND STEEL


Plates


Rivets


Boiler Lugs and Hangers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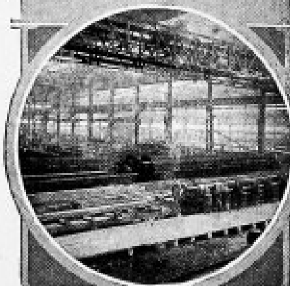
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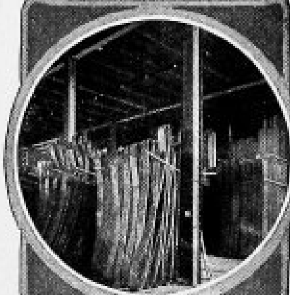
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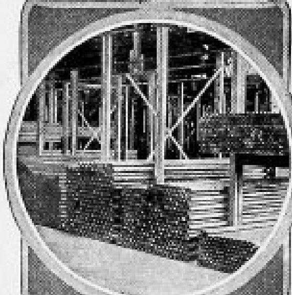
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The High Degree Superheater—Its Economy, Operation and Maintenance*

BY GILBERT E. RYDER †

During the past few years the trend in locomotive design in this country has pointed towards the heavier and more powerful unit, to meet the demands of constantly increasing freight and passenger traffic. Together with the increasing size of locomotives every effort has been made to produce an engine which would be able to operate with certainty and with the least amount of time out of service. To this end every device which would in any way be liable to cause a locomotive to fail in service has been considered very carefully before its introduction would be admitted to the design, and only such devices as are most stable have been used.

The development along these lines of capacity and continuity of service has produced locomotives of unprecedented power, satisfied reasonable demands for service, and has resulted in the production of a machine of remarkable quality. But until recently the question of thermo-dynamic efficiency has been one of secondary consideration. There are exceptions to this fact, but in general it is true that the attitude has been to develop power with any reasonable economy, but above all things to develop power.

With the size of the present locomotives and the belief of many that they had attained their maximum on account of the track and clearance limitations, other means were sought for the further increase of capacity and continuity. The successful operation of the high-degree superheater offered this means, and its introduction not only brought about an increase in capacity of from 30 to 35 percent, but made the machine from 25 to 35 percent more efficient. Not only that, but its introduction has had the effect of making the locomotive more reliable. Weather conditions and other adverse circumstances have not the influence on superheated that they have on saturated steam locomotives. These facts have led to the almost universal adoption of the high-degree superheater of the firetube type and its application to more than 75 percent of the locomotives that have been built within the last two years.

By the use of the firetube superheater the temperature of the steam entering the cylinders is about 600 or 650 degrees F., representing a superheat with ordinary boiler pressures of from 200 to 250 degrees. It has been proven by tests and by actual service conditions that the greater economies are obtained by high degrees of superheat. In one case, for example, at a boiler pressure of 180 pounds per square inch the coal required per indicated horsepower-hour with saturated steam was 3½ pounds; at 160 degrees of superheat the coal consumption for the same unit of work was 3 pounds, or a saving of ½ pound of coal, while with 220 degrees of superheat, or an increase of 60 degrees, this same saving was again realized, and the coal burned per indicated horsepower-hour was 2½ pounds. Inasmuch as the higher degrees of superheat are obtained when the engine is being worked the hardest, the figures also illustrate the fact that the greater economies are obtained when the engine is developing the most power or at a time when the highest efficiency of operation is most needed.

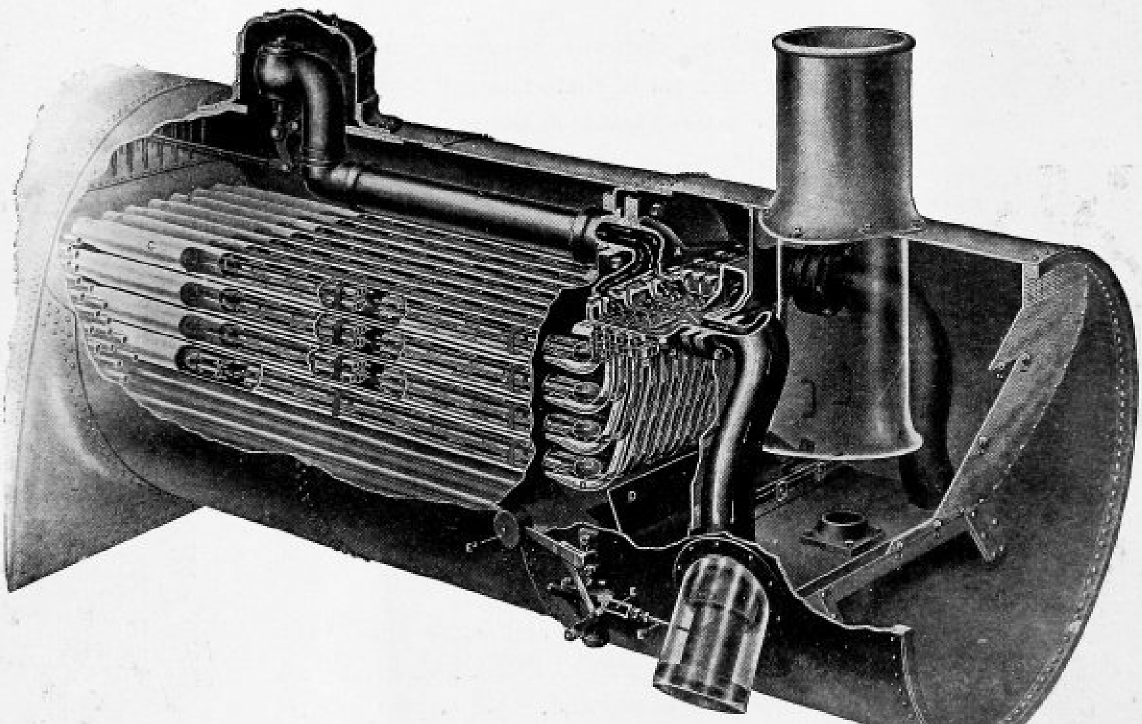


FIG. 1.—TOP HEADER FIRETUBE TYPE SUPERHEATER

Smoke-box types of superheaters, and other types which furnish only a moderate degree of superheat, have been tried, but their economy has not been sufficient to warrant their

* A paper read before the New England Railroad Club, Boston, Mass.
† Representative of the Locomotive Superheater Company, New York.

adoption. The smoke-box type is open to serious objection, in that it obstructs the front end, and it often has a tendency to clog up with cinders; this necessitates a high maintenance cost on account of the difficulty in cleaning and the deterioration of the pipes by the abrasive effect of the cinders. Many so-called "moderate-degree" superheaters produce in reality only a drying effect upon the steam as it passes through them, which is effective through only a small part of the piston stroke.

The advantages to be secured by the use of highly superheated steam are the increased volume of steam delivered per unit weight of water evaporated and the prevention of condensation between the boiler and the exhaust. The heat losses in the case of saturated steam result in condensation in the cylinders and in the passages from the boiler to the cylinders. This loss is greatest in the cylinders, where the variations in temperature are widest, and the large areas afford a favorable condition for the loss of heat, and therefore condensation, to take place. The lower temperatures in the cylinder walls are at the exhaust end of the cylinders or the admission end for the next stroke. In fact, the principle of operation of an engine is the most favorable to condensation losses, and the heat contained in the resulting condensed steam is lost for further work. This condition is not true where high degrees of superheat are used, for while the heat interchanges may be the same in amount the heat lost reduces the superheat and affects the pressure only as the pressure of a gas is affected by change of temperature. This loss in pressure is practically negligible.

Since with the superheater condensation losses are entirely eliminated, the demands upon the boiler in developing the same power are less, and the capacity of the boiler is increased in proportion as the demands upon it are decreased. As the demand for power increases, the degrees of superheat increase, the volume per unit weight increases so that the amount of water which is required per unit of work is reduced. This reduction has been found to be from 30 to 35 percent, which means an equivalent reduction in coal burned to the extent, in many cases, of 25 percent; the difference in these percentages being accounted for by the heat absorbed by the steam in passing through the superheater. By the utilization of this saving, or, in other words, if the same amount of coal is burned, the real value of the superheater in assisting the progress of higher powered locomotives is attained by a resulting increase in hauling capacity of 33 percent.

Another feature which the lack of condensation in the superheater engine favors is larger engine cylinders and lower boiler pressures. Since the size of cooling surfaces of the superheater engine requires no consideration from the fear of condensation, as it does in saturated engine design, the cylinders may be made as large as is necessary to develop the same power with lower boiler pressure; thus the life of the boiler is prolonged and maintenance costs in connection with it are very much reduced.

The superheater itself to be satisfactory must be simple, efficient and accessible. The top header firetube type furnishing highly superheated steam is designed and constructed with those requirements in view. It is made up of an integral header which in no way obstructs the front end or interferes with the maintenance of the boiler flues, so designed as to cause the least tendency towards wire drawing of the steam; an arrangement of superheater tubes which makes them easily accessible and removable, and so constructed that the unequal expansion caused by the difference in temperature as the steam passes through them will be taken care of, and a set of superheater flues located in the upper part of the boiler where the tendency towards clogging is least and the temperature is highest.

The superheater assembled, Fig. 1, consists of a header *"A"* supported on brackets in the smoke-box and making a joint with the steam pipe in the same manner as the Tee head used in the saturated engines. Attached to the header and in communication with it are the elements or units *"B,"* made up of cold-drawn seamless steel tubing and screwed into return bends. Each unit is located inside a large flue *"C,"* and extends to within about 2 feet of the back flue sheet.

The flow of gases through these flues is controlled by a damper *"D,"* which is operated by the damper cylinder *"E,"*

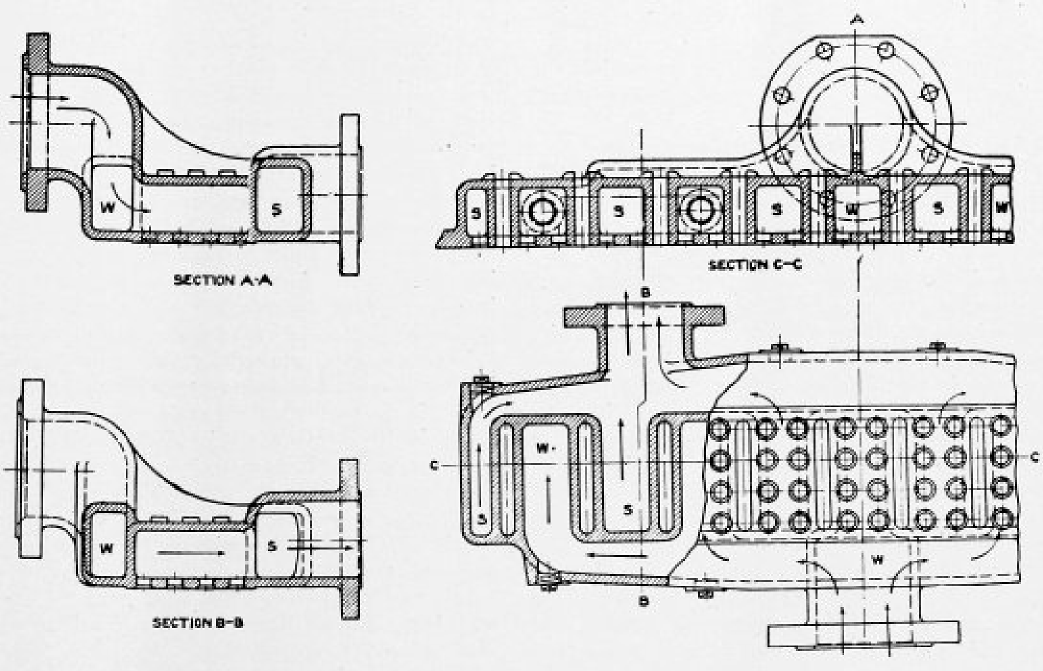


FIG. 2.—DETAILS OF HEADER CASTINGS

located at the outside of the smoke-box. The normal position of the damper is open when the engine throttle is open, thus allowing the gases to pass through the large tubes and come in contact with the superheater units.

The deflecting plate "*F*" is in a vertical position, and this, in connection with the horizontal partition which extends from the deflecting plate to the front flue sheet and contains the damper, makes the complete enclosure for the header and the part of the superheater units which extends through the front flue sheet in the smoke-box. The deflecting plate is made in parts to be easily removable.

The operation of the superheater is as follows: First, when the throttle valve is open saturated steam passes through the dry pipe and into a portion of the superheater header designed to receive the saturated steam. From this portion of the header, which is in communication with one end of the superheater units, the steam passes downward through one tube of the unit, backward toward the fire-box tube sheet, forward and backward again, and then forward and upward into another compartment of the header designed to receive the superheated steam. From the header it then passes into the steam pipes, then into the steam chest and the cylinder, where the effective work is done.

The flow of gases from the fire-box through the large flues is controlled by a damper. The position of the damper when the engine is not working steam is closed. At the opening of the throttle valve steam is admitted to the damper cylinder "*E*" through pipe *E*-1, which is in direct communication with the steam pipe and damper cylinder. This automatically opens the damper by means of a bell crank connection between the damper piston rod and the damper shaft. Simultaneously with the operation of the damper the counterweight *E*-2 is raised to the position shown in the illustration, from which position it will fall when the steam is shut off and the damper will again be closed. The opening of the damper provides for the flow of heated gases from the fire-box through the large flues. The reason for the introduction of the damper system is to protect the superheater tubes against overheating while no steam is flowing through them to absorb the heat.

Fig. 2 shows a detailed view of the header casting through several sections. Section through *AA* shows a portion of the steam pipe connection of the header and the passageway, and also the back and front end passage for the saturated and superheated steam. The passageway marked *S* represents the superheated, and that designated *W* on the saturated steam passageway, which are in communication with the respective chambers marked *S* and *W* in the section *CC*. The units are held in place by bolts which extend through slots in the header casting between the superheated steam and saturated steam chambers, and the bolts are prevented from turning by bosses or lugs located on the top face of the header. The section through *BB* shows a section of one of the top steam pipe connections, and is similar in other respects to section *AA*. In the plan view of the lower side of the casting is also shown a part cut-away to indicate the arrangement of the saturated and superheater steam chambers and the direction of the flow of the steam through their passages.

The superheater unit and the ball joint connection, together with the clamps for holding the joints in place in the header, are shown in Fig. 3. The ball connection on the end of the tubes are each ground to fit the seats in the header casting and clamped to the header. This clamp is supplemented by a ball-ring fitting under the ball of the tube in a manner that provides for any irregularity that may occur in the bending of the tubes or in the depth of the seat in the header. The return bends are of cast steel, and are provided with lugs which rest against the inside of the large flues and keep the superheater units in the upper part of each flue.

The superheater tubes, it will be noted, may be easily removed and replaced, and in doing this it is not necessary to take down the steam pipes. It is also possible to thoroughly inspect the front end and do all necessary work on the boiler flues, boiler tubes and the front tube-sheet seam without the necessity of taking down the superheater header or the steam pipes. A hand-hole opening is usually provided on the smoke-box sides through which inspection may be made of the entire front end of the superheater by the aid of a light without taking down the front end netting or even opening the smoke-box door.

The detail construction of the damper and damper cylinder which operates it are shown in Fig. 4. In the first position the throttle is closed, while in the second position the damper and throttle are open, allowing the hot gases to pass through the large flues and come in contact with the superheater unit pipes. From this brief description of the construction of the top header firetube type superheater, it will be noted that the lines of simplicity and accessibility have been carefully followed, and successful operation of the superheater locomotive has demonstrated its efficiency.

To obtain the best results with the superheater locomotive there are very few principles of operation which would not apply to the most economical methods employed in running a saturated steam locomotive. In starting, after the engine has been standing for some time, the cylinder cocks should be opened and kept open until dry steam appears, and in order that this practice will be assured the rule should be followed of opening the cylinder cocks during every start, thus eliminating the possibilty of ever working water that may be condensed in the cylinders standing. It is recommended also that the engine be put in full gear when starting, in order that the valves may travel throughout the entire length of the bushings and insure the distribution of oil over their entire surface. In general, after the engine is started and well under way a full throttle is advised. While running, the full throttle is recommended, because with a very small throttle opening the wire drawing of the steam requires a longer cut-off to develop the same power. This longer cut-off means a greater weight of steam, together with the correspondingly more water and coal required to generate the steam.

It is a well-known fact that with many locomotives there is a tendency to work water over the throttle stand into the dry pipe and then to the cylinders. While it is highly improbable with the fire-tube superheater that water will ever be worked into the valves and cylinders, yet the efficiency of the superheater may be greatly reduced by the practice of carrying the water too high in the boiler. There is nothing in the construction of the superheater to prevent the water from entering the throttle pipe in the same manner as it does in a saturated engine, but should this occur it would be carried on into the superheater units, a part or all of whose surface will then necessarily be used to evaporate this water, and the degree of superheat obtained is reduced in proportion to the amount of water carried over. For this reason the water should be carried as low in the boiler as safety will permit and individual engine conditions will allow.

On account of the decreased amount of steam by weight required it has been found that superheater engines will operate more economically and steam more freely with a smaller exhaust nozzle than saturated engines developing the same power. A smaller nozzle produces a sharper draft on the fire, consequently a higher fire-box temperature and a correspondingly higher degree of superheat. It is the practice on one road that has a large number of superheaters of the fire-tube type, and are applying several superheaters to old engines each month, arbitrarily to reduce the nozzle area 10 percent upon the application of the superheater. These engines steam freely and show no tendency to choke themselves by too much compression. In fact, the smaller exhaust tip adds to rather than detracts from the smartness of the machine.

In the operation of the superheater engine the question of lubrication has been one that has required some attention—not that it is much more difficult to lubricate a superheated steam locomotive than a saturated, but due to the fact that it will not permit the neglect that the saturated engine will on account of the higher temperatures of the parts in contact with the steam. If the steam-chest bushings and the valve rings are made of a good grade of homogeneous, fine-grained metal, and are fitted properly, lined up correctly and oil admitted to them regularly, there is no danger of cutting while the engine is working steam, but if the steam is suddenly shut off while the surfaces are at a temperature above that of the flash point of the oil there is but one result that can take place, which is the carbonization of the oil, and if the parts are run long enough in this dry condition they will start to cut. To overcome this condition the engines should be allowed to drift with the throttle slightly open.

As a source of oil supply on a two-cylinder simple engine, a five-feed lubricator has been found to give good results, feeding oil to the valves and cylinders at a rate of three or four drops to the valves to one drop to the cylinders. The actual amount of oil to be fed to the valves and cylinders is a matter which is largely governed by the individual conditions existing on the various roads, and should be worked out carefully for each particular case before a standard allowance of oil is specified. A standard practice should be followed in connecting up the lubricators so that the same feeds will be connected to the valves and cylinders on all engines on the same road, and as a means of further precaution the destination of each feed should be designated by a label attached to the adjusting valve of this feed on the lubricator itself. As to the quality of oil to be used little may be said further than that it should be of good quality, having a considerably higher flash point than is ordinarily used in saturated locomotive practice.

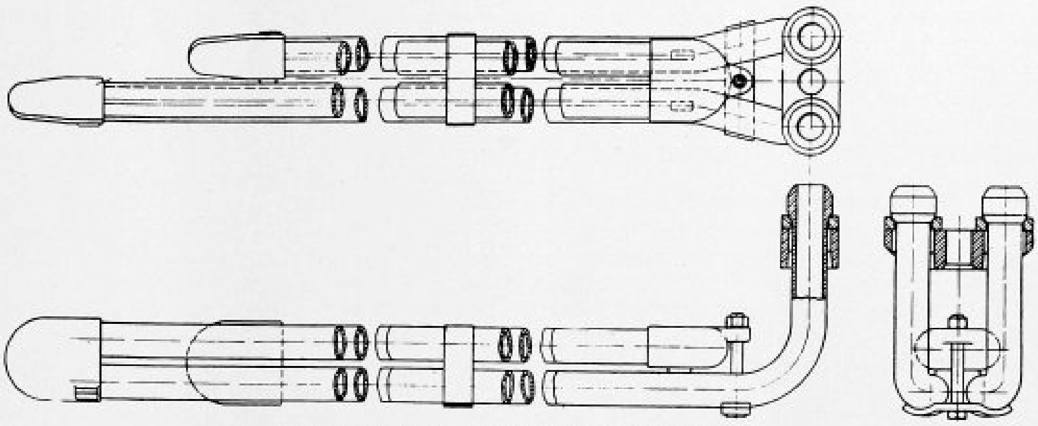


FIG. 3.—A SUPERHEATER UNIT AND BALL-JOINT CONNECTION

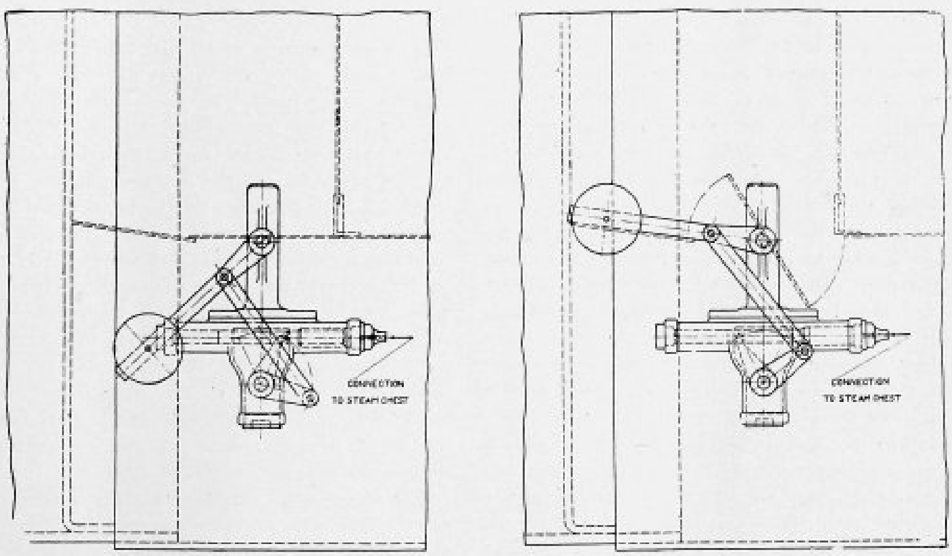


FIG. 4.—DAMPER AND DAMPER CYLINDER

Finally, in regard to the operation of the superheater locomotive there is the question of proper firing. On this subject very little need be said portending to recommend methods beyond those to be practiced to produce perfect combustion. Perfect combustion in the fire-box, of course, means the highest efficiency of the fire, and in proportion as this condition is approximated, so is the fuel economy of the road improved. Perfect combustion also means the highest fire-box temperature, which it has been shown increases the degree of superheat produced by the superheater. Briefly, then, the most perfect combustion of the ordinary kinds of bituminous coals used in locomotive service can be obtained by firing light and regular, never putting green coal on green or unignited coal, and never allowing holes to remain in the fire. Additional practice—for example, shaking the grates, hoeing or slashing the fire and the actual thickness of the fire—must be governed by the character of the coal burned. Any economical device which favors higher fire-box temperatures is of value for use in connection with the superheaters. To this end the brick arch gives excellent results on superheater locomotives. It aids in effecting a more perfect combustion of coal by lengthening the flame way, retarding the flow of gases and acting as a baffle wall, thereby giving the gases more time to mix with the oxygen in the air; and as a baffle wall assists the mixing, thereby completing the combustion which results in the desired high fire-box temperatures.

The operation of the superheater locomotive and its maintenance are closely associated, and to obtain the highest efficiency in operation with the superheater, as with anything else, some attention and care must be given to it. There is nothing about the detail construction of the superheater the maintenance of which is peculiar to the superheater. All its parts are assembled by methods that are in general use in locomotive construction throughout the country. In respect to the individual parts, it will be found that they require no more attention, and in many instances less, than do corresponding parts in locomotives without superheaters. Large flues, which are set in the sheet in the same manner as the smaller ones, except that copper ferrules are used and the holes in the flue sheet chamfered do not require any more attention as far as maintenance is concerned than the smaller ones do, and on account of their increased gage, compared with the smaller tubes, do not need to be renewed or safe-ended so often. With respect to keeping these flues free from deposit of ashes and cinders, there is some additional labor entailed. The extent of this labor is dependent almost entirely upon the nature of the coal used. With some classes of coal the large flues will need cleaning only at long intervals, while with other coals they must be cleaned very frequently in order to get the best results from the superheater. The intervals at which the flues should be cleaned must be determined in each case individually. When this interval has been established, whether it be every trip or every ten trips, the schedule should be made and adhered to strictly. The method found to be best adapted to cleaning the flues is by means of a long nozzle made of about ½-inch pipe and of sufficient length to extend entirely through the flue. The nozzle pipe may be connected by means of an air hose to the air line in the roundhouse, which should furnish air at of least 100 pounds pressure in order to get the best results in cleaning the flues. This pipe nozzle inserted in the fire-box end of the flue and pushed forward will remove all the loose deposit of cinders and soot, but in order to remove the ash or honeycomb deposit which accumulates on the back return bends with some varieties of bituminous coal, it is often necessary to use a hook designed to break the honeycomb away from the bends and pull it out. The importance of keeping these flues free cannot be emphasized too strongly, for they represent a large proportion of the water-heating surface of the boiler as well as control the superheating surface, and their stoppage greatly impairs the steaming qualities of the boiler.

In maintaining these large flues on engines in service it is found advisable to give preference to the prosser and to use the roller on the flues only when it is absolutely necessary. The prosser found to give satisfactory service in maintaining these flues consists of twelve sections, the contour of which conforms to the prosser ordinarily used in working small boiler flues. In regard to the beading tools used to maintain the beads on the large flues, care should be taken to see that they are made to fit the bead, which on account of the gage of the large flues are larger than the beads on the small boiler tubes. It has been found in some cases that beading tools designed for the small boiler tubes have been used on the large flues, and this practice tends to destroy the bead by cutting a shoulder around the outside edge of it, which, if the practice is continued long enough, will be entirely cut away.

Inasmuch as there are a large number of steam-tight joints in the smoke-box, this part of the engine should be inspected often in a general way by means of the hand-hole plate in the sides of the smoke-box. At regular intervals (every thirty days is recommended) the smoke-box door should be opened, the deflector plate removed, and a thorough inspection made of the inside of the smoke-box to locate any steam leaks that may occur in the ball-joint unit connections to the header, the steam pipes and the dry-pipe connections, or air leaks in the smoke-box itself. These should be carefully stopped in order to improve the steaming qualities of the engine. It is a good practice at the first thirty-day inspection of this kind made to new engines that have been just put into service, or engines recently out of the shop where the units have been disconnected from the header, to go over the tube bolts to determine that they are all turned up as tight as they should be. There is a possibility that these bolts may have stretched or the heads settled down a little in the slots, due to stresses set up by the expansion and contraction of heating and cooling of the parts, and a little precaution in tightening them up at this time may save a serious leak which would necessitate the removal of one or more of the units. At intervals of sixty days the superheater should be given a water test by filling it with warm water at about 100 pounds pressure, to determine by this means that no leaks have developed in the steam joints in the front end. These tests are imperative from the fact that it has been found in operating superheater engines that a considerable leak can exist in the smoke-box without seriously interfering with the steaming qualities of the engine, and unless this leak is determined soon after it occurs it may not only have a cutting effect upon the seats at the point of the leak, but the jet of steam may also injure adjacent tubes, flue sheet or other parts. In case a unit fails, or a leak occurs in one of the ball-joint connections on engines in the roundhouse that are needed for immediate service, the leaky unit may be removed and the dummy coupling inserted which will blank off both openings in the header and the engine be permitted to go into service. These dummy couplings are for emergency purposes only, and may be carried in stock at the several roundhouses, especially points where repairs cannot be made, serving the superheater engine for this purpose. It should not be a practice of introducing these dummy couplings for permanent service, inasmuch as the removal of a unit impairs the efficiency of the superheater, but only until the unit can be repaired or a new one prepared and put in place of the defective one, and to this end a careful record should be kept of all dummy couplings applied.

The damper and rigging should be inspected and adjusted to work freely. As previously stated, the damper should be wide open when the throttle is open and there is steam in the damper cylinder. With no steam in the damper cylinder or when the throttle is closed the damper should be closed.

Again, regarding the large flues, in the course of time it will become necessary to renew or safe-end them. This operation is in principle accomplished in the same manner as the small tubes are safe-ended, differing in that the large flues have the safe-end welded on the small or fire-box end of the flue. By using this end of the flue a saving in material is effected, and a reduction in the difficulties experienced in welding the safe-end on the large diameter flue. The process is the same as that employed in safe-ending the small boiler tubes.

The life of the superheater unit is much greater than that of the boiler tubes. In fact, experience with the superheater in

American railway service has not been extended enough to know exactly what the life of these units is, but it is estimated that it should be at least equal to three new sets of boiler flues. As a rule the units require no attention when they are removed from the engine at the time of shopping for general repairs other than to clean up the ball-joints on the unit tubes and the corresponding seats on the header, and to regrind them in order to insure a steam-tight joint when they are returned to the engine. A grinding cup, made of material that has proven most successful for grinding purposes in any particular railway shop, having the contour of a sphere and operated by an offset spindle, has been found to give satisfactory results in grinding the balls on the ends of unit tubes. In case these balls may have been damaged in their removal from the engine, or have been cut deeply by a leak which may have been overlooked while the engine was in service and required more attention than merely grinding, a revolving cylindrical scraper made in much the same manner as the grinding cup and operated with an offset spindle may be used with satisfactory results. This scraping process, of course, should be followed with the grinding tool. For grinding the seats in the header a ball grinder, the ball having the same diameter, or a diameter a very little larger than that of the grinding cup, may be used.

The maintenance of the remaining parts of superheater equipment varies little from locomotive practice with other parts of the locomotive, and their construction is sufficiently simple to be self-evident to any mechanic. One more precaution, however, may be mentioned pertaining to the storing of engines in cold climates where freezing is liable to occur. Under these conditions the superheater tubes should be carefully blown out after the boiler is cold to remove such water as may have condensed in them, which would be liable to freeze and burst the tubes.

Along with the superheater, and operated well in connection with it, there have been other developments which work for higher efficiency and convenience of operation. The piston rod extension has been found to be of considerable value in reducing the wear of cylinder bushings and piston packing rings by relieving the bushings and rings from the weight of the piston and allowing it to float in the cylinder supported by the cross-head guides on one end and the piston rod extension guides at the other. A very practical design of piston rod extension was brought about by Mr. F. J. Cole, chief consulting engineer of the American Locomotive Company, and has been giving satisfactory results in service on many superheater locomotives during the past year. This piston rod extension meets the requirements of what a device of its kind should be, in that its construction is simple, rigid, easy to lubricate, easily removed without interfering with other parts of the locomotive, and, above all, it is supplied with ample bearing surface, a feature which has been lacking in the earlier designs of piston rod extensions.

This piston rod extension operates on the principle of a miniature cross-head on the front end of the piston rod, riding on a cylindrical guide which is rigidly bolted to the cylinder head in a manner that makes it self-centering and easily located. The cross-head shoe may be kept in line by the introduction of liners between the shoe and the body of the cross-head to compensate for any wear that may take place. Another feature of the design is that the guide is made open at the top, so that in case it may be necessary to remove it it may be dropped down over the piston rod, thereby requiring space ahead of the cylinder equal only to its own length. On account of the high temperatures of the cylinder walls where superheated steam is used and the greater liability of damage to these walls should the lubrication become inefficient, the use of the piston rod extension is advantageous on superheated steam locomotives.

Another change in the construction of locomotives which favors the convenience in location of the superheater, and which is being adapted quite generally on these locomotives throughout the country, is the introduction of outside steam pipes. Outside steam pipes also offer a greater clearance in the lower part of the smoke-box, affording a better opportunity for drafting the engine, as well as making the operation of cleaning the front end much simpler. Not only is the convenience evident in this arrangement, in that it removes an obstruction from the smoke-box, but it makes the operation of the locomotive more positive by permitting the two lower steam pipe joints to be located outside the front end, where failure may be more readily detected, and where leaks will have but little effect upon the steaming qualities of the engine. With the old arrangement of inside steam pipes a comparatively small leak in the lower joints will seriously affect the steaming of the locomotive. Further advantages are obtained, in that the absence of steam passages in the cylinder and saddle casting not only simplifies the casting itself, but it reduces the stresses and the heat interchanges which are set up by the difference in temperature on opposite sides of the same wall in the ordinary casting. Inasmuch as the temperature of superheated steam is much higher than saturated steam these stresses and losses are proportionately larger, and for this reason, as well as the convenience of the front end, the outside steam pipes are particularly adaptable for use with superheater locomotives.

It has been the purpose of this paper to point out some of the advantages of the use of highly superheated steam in locomotive practice, to take up a type of superheater constructed on the fire-tube principle with the top header, and cover briefly a few of the principal points in its operation and maintenance. In summing up the subject, the adoption of the high-degree superheater has been influential in introducing into American railroad practice other new features which work toward economy. The top header fire-tube superheater, furnishing highly superheated steam results in a saving in fuel of 25 percent and in water consumption of 35 percent, and by the utilization of this economy indirectly a saving of over 30 percent, or an increased hauling capacity equivalent to the indirect saving. It has thereby increased the capacity of the present saturated locomotive, which had reached its limit, measured by the capacity of the fireman, to the extent of the indirect saving, or about 30 percent. It has produced a more powerful engine per unit of weight than had been attained up to the time of its introduction into locomotive practice. The fire-tube, top-header type of superheater is simple in construction, efficient in operation and accessible for maintenance, and is maintained at a low cost.

Tube Ruptures

Tube ruptures in watertube boilers cause serious personal injuries or loss of life, entail considerable property damage and occur all too frequently.

Such ruptures are due either to material that was originally defective or which subsequently became defective because of being subjected to continual heat, or which became defective by pitting or corrosion, or which became weakened by overheating, due to low water or to the forcing of the boiler too far beyond its rated capacity.

When the rupture occurs the fireman has to suffer, and frequently the rupture of a single tube allows all of the water to escape from the boiler, as a result of which the entire boiler is damaged beyond repair.

Tubes in watertube boilers should be carefully inspected and thoroughly hammer-tested to determine their condition; and whenever there is reason to believe that the tube material has lost its ductility by reason of its long service in the heat of the furnace, or is otherwise defective, the tube should be replaced by a new one having proper strength and ductility.—*Monthly Bulletin of the Fidelity and Casualty Company.*

Investigation of Locomotive Boiler Explosion at San Antonio, Tex.*

On March 18, 1912, the Southern Pacific Company, in response to a wire from this office, confirmed newspaper reports of an explosion of the boiler of Galveston, Harrisburg & San Antonio locomotive No. 704, which occurred near the latter company's engine house, San Antonio, Tex., at 8:55 A. M., March 18, 1912, resulting in the death of twenty-six persons and injuries to thirty-two others. The number of those injured does not include those who suffered from shock only.

The locomotive in question—a heavy passenger locomotive of 4-6-0 type, using crude oil for fuel—was owned and operated by the Galveston, Harrisburg & San Antonio Railway Company. It was built in March, 1908, by the American Locomotive Company at their Brooks Works, builder's number being 45,067. The fire-box was of three-piece construction crown-bar type. The working steam pressure was 200 pounds per square inch. The barrel of the boiler was made of steel, three-quarters of an inch in thickness, in three sections or courses, constructed with butt longitudinal joints with diamond-shaped welts. The dome was located on the third course. The wrapper sheet was ⅝-inch steel, the back head sheet ½-inch steel, the back flue sheet ½-inch steel, and the fire-box door sheet, crown and side sheets ⅜-inch steel. The fire-box was stayed with rigid bolts of ⅞-inch diameter at ends, reduced to ¾ inch at center of bolts, four rows of Tate flexible bolts of 1-inch diameter at top of fire-box and two rows at each end, staggered at top corners. The crown bolts were driven fit with countersunk heads, 1⅛-inch diameter at the bottom end and 1-inch diameter at the top end, extending through crown bars with nuts on top. The crown sheet was supported by fifteen crown bars, which were supported from wrapper sheet by 168 sling stays, ⅝ inch by 3 inches, and twelve sling stays ½ inch by 2¾ inches. The flues, numbering 355, were of 2-inch diameter. The boiler was equipped with three 3-inch Crosby safety valves. The locomotive had been in shop for several days and was being prepared for service.

At the time of the explosion the locomotive was standing between the blacksmith shop and coppersmith shop, and an employee of the railway company was engaged in setting the safety valves. The force of the explosion was such that the boiler was literally blown to pieces. One piece, consisting of wrapper sheet, 21 feet 4 inches wide and 10 feet 9 inches long, with 12 feet of mud-ring, 4½ inches by 5 inches, attached to the same, as well as the dome and a portion of the dome course, 5 feet 9 inches by 14 feet, together with a portion of the second course, the total weight aggregating approximately 16,000 pounds, was carried ahead and to the right a distance of about 1,200 feet. The boiler head, which was 6 feet 6 inches wide and 8 feet in height, weighing approximately 1,250 pounds, was hurled in the opposite direction a distance of 1,200 feet, passing through the back and side walls of a two-story frame residence. A part of the first course, the weight of which was approximately 900 pounds, was also carried ahead and to the right a distance of about 2,250 feet, and was buried in the ground over 5 feet. A piece of the second course, 60 inches by 72 inches, weighing about 900 pounds, was blown through the walls of the blacksmith shop and fell about 75 feet from the scene of the accident. The remaining portion of the boiler, consisting of the smoke-box and front flue sheet, a part of the first, second and third course and throat sheet, also the back flue sheet and about 150 flues, were torn from the locomotive frame, falling bottom upward about 25 feet forward from where the locomotive had been standing. The crown sheet, with flange of flue sheet and one-half of the door sheet, were blown down between the frames, as were also the side sheets of fire-box. Six crown bars remained attached to the crown sheet, the rest of the crown bars—nine in number—being torn away from the crown sheet and wrapper sheet. The side sheets were torn into three pieces, approximating 200, 500 and 600 pounds in weight, respectively. Both of the driving wheels were forced off the back axle, which was broken about 2 inches inside of the right-wheel center and 6 inches from the end thereof. Both of the main driving wheels were started on the axle, the frames bent and twisted; both piston rods and the top of the cylinder saddle were broken. The tender was broken from the locomotive and blown backward about 100 feet.

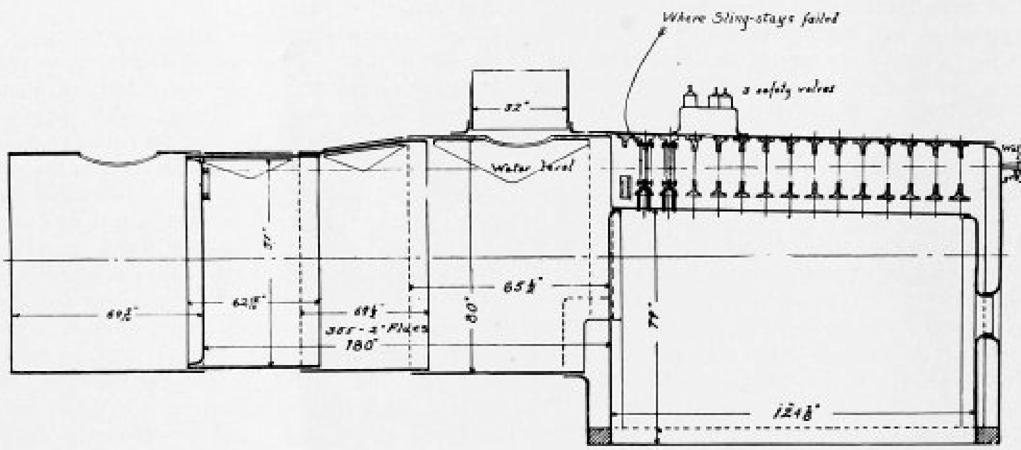


FIG. 1.—DIAGRAM OF BOILER

The property damage was estimated to be about $47,250—$12,000 to the locomotive and $35,250 to the following buildings:

The coppersmith shop, the dimensions of which were 20 by 40 feet, was destroyed. The blacksmith shop roof was blown down and 75 feet of both walls. The machine shop roof was

* From the report of John F. Ensign, chief inspector of locomotive boilers, Washington, D. C.

blown down and 15 feet of the wall. A corner of the roundhouse, consisting of about 45 feet of wall and section of roof, was destroyed. Boiler shop roof was damaged by the falling missiles and all window glass in shop buildings was browen. Residence on Sherman street had end and side torn out. Vacant house on North Cherry street unroofed and front wall blown down. Residence on Milan street, hole torn in roof. Residence at corner of Austin and Mason streets, roof and floor damaged.

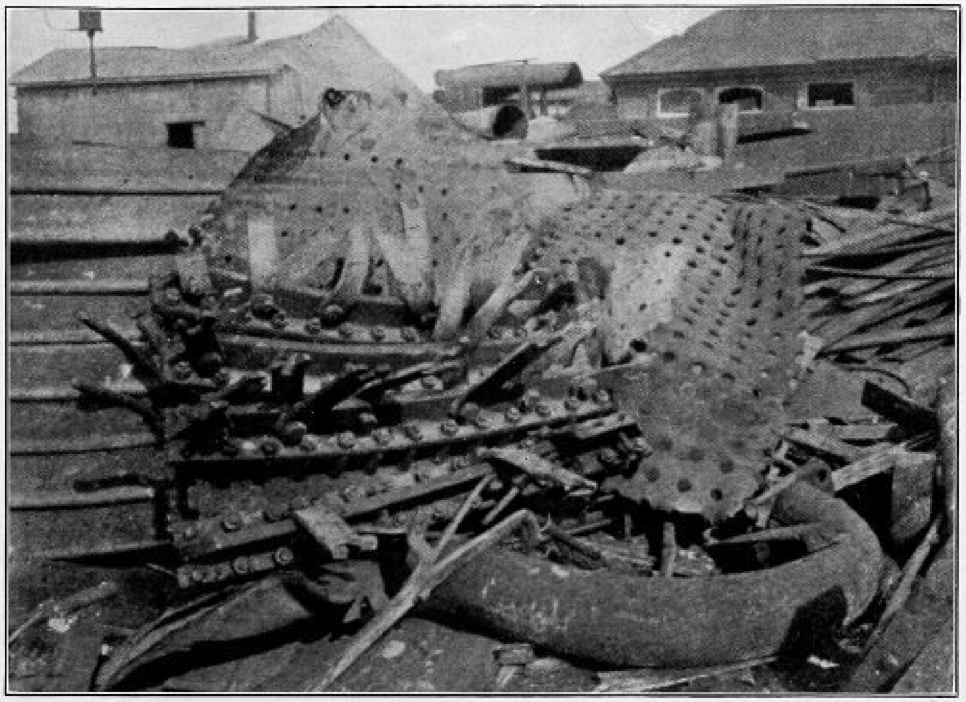


FIG. 2.—VIEW OF TOP OF CROWN SHEET, SHOWING MANNER IN WHICH CROWN BAR SLING STAYS GAVE WAY

An investigation, in which we received valuable assistance from the Hon. Allison Mayfield, chairman of the Railroad Commission of Texas, was conducted in the Federal court room at San Antonio, on March 22, for the purpose of obtaining sworn statements from all persons who had any knowledge of conditions preceding this explosion, the following witnesses being called on to testify: H. M. Nichols, night roundhouse foreman; Horace Lewis, day hostler; C. R. Farrington, boiler inspector; W. V. Steimel, chief clerk to master mechanic; J. E. McLean, assistant superintendent (master mechanic); W. A. Howard, fireman; George Helman, boiler maker foreman; Horace Mansfield, machinist; A. Bushen, fire builder; J. W. Small, assistant general manager (superintendent motive power), and W. N. Stark, general boiler inspector.

Briefly summarized, the evidence brought out the following facts: Locomotive was out of service from Feb. 21 to March 18, 1912, for repairs, during which time the following boiler work was done: Two hundred flues reset, 1 back head brace repaired, 1 front flue sheet brace and 2 throat stays repaired, 8 stay-bolts renewed, safety valves ground in, steam gage tested and hydrostatic test of 250 pounds pressure per square inch applied. Repairs were completed about 5:45 P. M., March 17, and locomotive fired up, but no steam was raised. The locomotive was again fired up about 6:10 A. M., March 18. Safety valves first opened at 7:30 A. M., at which time steam gage registered 50 pounds pressure. Safety valves were screwed down and again opened at about 8 A. M., when gage registered 150 pounds pressure. There is no evidence indicating that the safety valves opened at any time subsequent to 8 A. M. The locomotive had a heavy forced oil fire from 8 to 8:55 A. M., at which time the explosion occurred.

An employee of the railroad company was engaged in setting the safety valves at the time of the explosion, and although the evidence showed the gage had been tested there was no evidence that the siphon pipe leading from gage to boiler had been cleaned between the valve and the boiler, which is the point where it would be most likely to be obstructed; neither is there any evidence to show that the valve was open.

The damage to the boiler, as well as the direction in which the various parts of the boiler were blown, indicate conclusively that the fire-box sheets were the first to give way, as the boiler head was blown backward and all other parts of the boiler were blown forward, the flues, flue sheets and smoke arch being simply turned over forward and thrown to the left, while the wrapper sheet with a part of the dome course with the dome attached and other pieces of the shell sheets were blown for long distances forward and to the right.

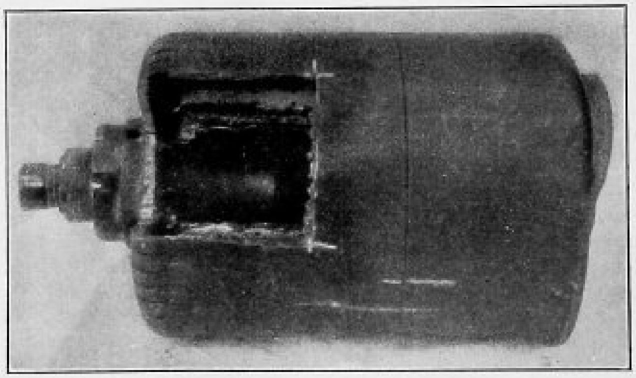


FIG. 3.—SAFETY VALVE CASING, SHOWING ABSENCE OF LOCK NUT AND BENT SCREW

Owing to the damaged condition of the safety valves and our inability to recover the springs and valves, a test thereof could not be made. The casings with the adjusting screws were found, one of which had no lock nut on it. The hexagon-shaped heads on the adjusting screws had the corners twisted off, after which a Stillson or pipe wrench had apparently been used in an effort to screw them down further. One of the adjusting screws was bent and the bottom end was upset or burred by the pressure that had been put on it. The condition of the threads on the adjusting screws indicated that they had been recently screwed down more than five-eighths of an inch. Reasonable knowledge of the purpose and construction of safety valves should prevent work being done on them which would cause such conditions.

A careful examination of the crown-bar sling stays shows that they were made of wrought iron, while the specifications called for steel. The sling stays were badly stretched and reduced in section at the eyes where they failed, indicating a gradual rise of pressure in the boiler.

Five 1-inch bolts were used to attach the sling stays to the crown bars and to the wrapper sheet, where 1¼-inch bolts

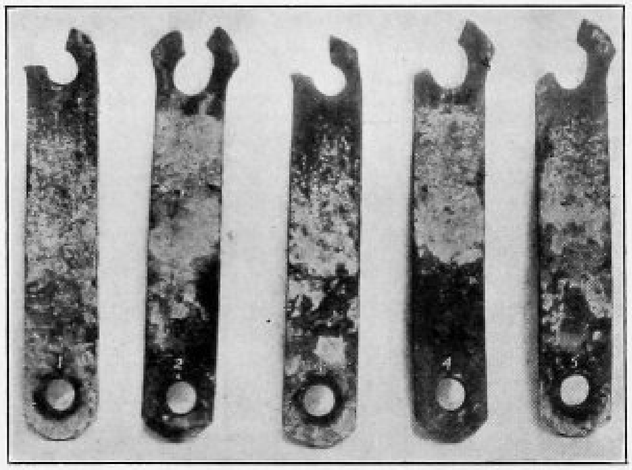


FIG. 4.—CROWN BAR SLING STAYS, SHOWING HOW THEY GAVE WAY

should have been used; 1¼-inch bolts were specified on the drawings, except on the front crown bar, where 1-inch bolts were specified. The crown bars in this boiler were not supported on the sides of the fire-box, as was customary in the older type of crown-bar boilers, therefore all the support was from the sling stays.

Five crown-bar sling stays from locomotive No. 704 were tested by the United States Bureau of Standards to determine the load the stays would support when 1-inch and also when 1¼-inch bolts were used. The bolts used in making these tests were those which were in use in the boiler at the time of the explosion. Two stays, Nos. 1 and 2, tested with 1-inch bolts, failed with a total load of 26,650 and 21,840 pounds, respectively. Three stays, Nos. 3, 4 and 5, tested with 1¼-inch bolts, failed with a total load of 30,000, 33,890 and 31,620 pounds, respectively.

Using 21,840 pounds as the strength of the sling stays having 1-inch bolts, we find the stays have a factor of safety of only 2.67, and using the highest test figure of 26,650 pounds we find the factor of safety to be only 3.26. Calculation shows that sling stays, fitted with 1¼-inch bolts, had factors of safety of from 3.67 to 4.15. The tensile strength of the material in the sling stays was shown by test to be 43,200 to 48,300 pounds per square inch and the elongation 18 to 40.5 percent in 2 inches. Tests of the sling stays show that the failure was caused by the bolt holes being drilled too near the ends of the stays.

Eighty-six stay-bolts, 9 of which were in left side, 63 in right side sheet and 14 in flue sheet, were found broken at the wrapper sheet and adhering to the fire-box sheets. Twenty-six of these stay-bolts were found to have been fractured, *i. e.*, partly broken before the explosion. The remaining 60 were in such condition that it cannot be positively stated that they were fractured prior to the accident, but the fact that they broke at the wrapper sheet and did not pull through the fire-box sheets indicates a defective condition. Three stay-bolts taken from this boiler were tested by the United States Bureau of Standards, and the material was found to be of good quality.

The above facts, in our opinion, indicate the reasons for the fire-box giving way first.

The steam gage and its connections were destroyed, so that an inspection of them could not be made, but it is probable that the steam gage did not indicate the correct pressure. This could be caused by a defective gage or some obstruction in the

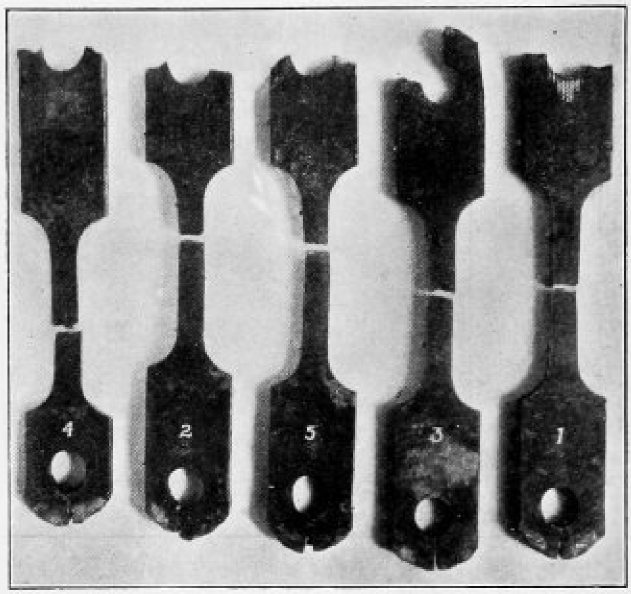


FIG. 5.—CROWN BAR SLING BARS, SHOWING HOW THEY FAILED UNDER TEST

siphon pipe, or by a valve in the siphon pipe being closed, or nearly so. An inspection of locomotive No. 702 of the same class disclosed the fact that it had *two* valves in the siphon pipe. When these valves were open the handle of one formed a right angle with the pipe and the other was parallel with the pipe. This arrangement of valves is very confusing and creates a dangerous condition, in consequence of which one of them was ordered removed. It is not known whether such an arrangement of valves existed on locomotive No. 704.

The evidence shows that the law and the rules governing the inspection of locomotive boilers were disregarded by the railway company's inspector and the officials in charge of such work at this point in the matter of making and properly certifying to the reports required by law. A report stating that the safety valves had been set was sworn to on March 16, 1912, by the railway company's inspector and the round-house foreman who signed it as the officer in charge of such work. The evidence shows conclusively that the safety valves had not been set at that time, and as a matter of fact it was while this work was being done, on March 18, that the explosion occurred. The evidence also shows that the inspector failed to witness the testing of the steam gage, and that the injectors had not been tested at the time this report was made out, notwithstand which facts he certified under oath that this work had been done.

The opinion was expressed at the investigation that nitroglycerin or some other high explosive was used, but nothing was found to support such an assertion.

The question has been raised by those who suggested this theory as to whether excessive steam pressure could cause such complete destruction of a boiler. The most violent explosions on record have been caused by excessive steam pressure. The destructive effects of boiler explosions is not caused by the steam alone, which is contained in the steam space at the instant the initial rupture occurs, but is due to the enormous quantity of steam which is instantly generated from the water contained in the boiler.

In the case of locomotive No. 704 the water level was high, the pressure very high, and the explosion was terrific. Careful calculations show that the stored energy in the boiler of locomotive No. 704 at the bursting pressure of the barrel was sufficient to raise the boiler approximately a mile high.

The flues and fire-box sheets show no indications of having been overheated, and the evidence showed that there were three gages of water at the time of the explosion.

It is our conclusion that this explosion was due to excessive steam pressure which was caused by an employee of the Galveston, Harrisburg & San Antonio Railway Company tightening the adjusting screw of the safety valves, resulting in an accumulation of steam pressure beyond the endurance of the boiler.

Tests made of the parts of the boiler which evidently failed first demonstrate that the pressure on the boiler at the time of the explosion was greatly in excess of the allowed working pressure. Therefore the steam gage, either on account of the gage itself being defective or an obstruction in the siphon pipe between the gage and the boiler, did not correctly indicate the pressure.

The railroad company was at fault in requiring or permitting inspections and reports to be made in a manner which was not in accordance with the law, and in allowing such important and responsible work as setting safety valves to be performed by an employee of whose experience and judgment the testimony shows they knew practically nothing, and in keeping a boiler in service for which the factor of safety, as shown by test, was below the recognized standard.

The rules governing the inspection of locomotive boilers, setting of safety valves, testing of gages and similar work are sufficiently comprehensive to insure safety if properly and intelligently complied with.

However, in endeavoring to obviate a recurrence of an accident of this character the necessary action has been taken making the use of two steam gages obligatory when setting safety valves, one of which must be so connected that it is in full view of the person engaged in setting such safety valves. Similar action has also been taken requiring the siphon pipe and its connections to the boiler to be cleaned each time the gage is tested.

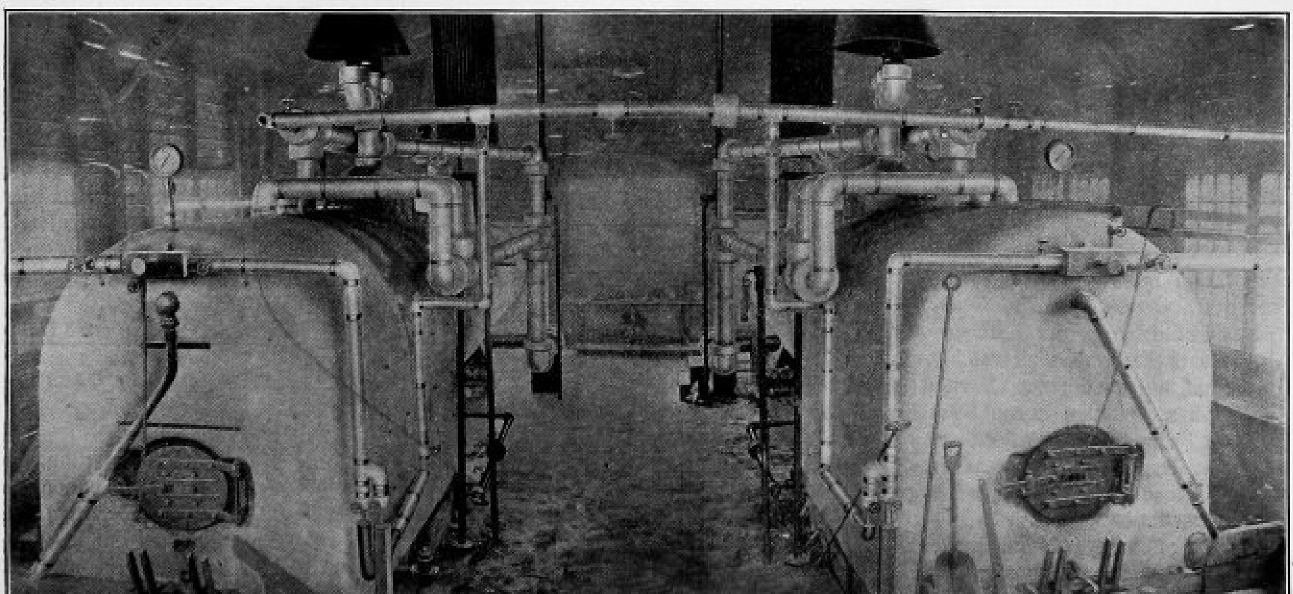
First Series of Comparative Tests Between a Stay-Bolt Fire-Box and a Jacobs-Shupert Sectional Fire-Box

As announced in our February issue, Dr. W. F. M. Goss, Dean of the College of Engineering of the University of Illinois, is supervising a series of comparative tests between a stay-bolt fire-box and a Jacobs-Shupert sectional fire-box at Coatesville, Pa. The tests of Series A of the outline approved, which are to determine the relative amount of heat absorbed by the fire-boxes of the two boilers under similar conditions, have been entirely completed, with results which in general terms are set forth as follows:

THE BOILERS

Two boilers have been employed in the tests, one having a fire-box of the radial-stay type, hereinafter referred to as the radial-stay boiler, and the other having a fire-box of the Jacobs-Shupert type, hereinafter referred to as the Jacobs-Shupert boiler. Both boilers are identical in their general dimensions, which are as follows:

Outside diameter of shell of boiler at front end .... 70 inches.



RADIAL STAY BOILER JACOBS-SHUPERT BOILER

Diameter of shell at throat........	83⅞ inches.
Number of 2¼-inch tubes.........	290
Length of tubes..................	218 inches.
Inside length of fire-box...........	109⅝ inches.
Inside width of fire-box...........	76⅜ inches.

The purpose of the tests of Series A was to determine for each boiler the evaporation from the fire-box and from the tubes separately. To make such a determination possible the back tube sheet was extended in all directions to the outside of the boiler, thus forming a diaphragm completely separating the water space on the two sides of this tube sheet. By this device each boiler was made in effect two boilers, the heating surface of one being all portions of the fire-box excepting the front tube sheet, and the heating surface of the other being the tubes and tube sheets.

In carrying out the tests each compartment was supplied with weighed water as though it were a separate boiler. The quality of the steam delivered from the fire-box end and from the barrel end was determined independently, the purpose being to determine with the highest possible accuracy the heat delivered through the walls of the fire-box and the heat delivered through the flues. The general dimensions of interest in this connection are as follows:

HEATING SURFACE SQUARE FEET

	Radial-Stay Boiler	Jacobs-Shupert Boiler
In the fire-box..............	179.2	201.9
In the barrel.................	2,805.1	2,806.5
Total for both parts of boiler.	2,984.3	3,008.4

TESTS WITH OIL

A series of oil-fired tests have been run on each boiler. Three different rates of power have been employed in each series, the rate of fuel consumption ranging from 800 pounds of oil per hour to 2,100 pounds of oil per hour. The total water evaporated from both the fire-box end and the tube end of the boilers has ranged from 10,000 pounds per hour to 24,000 pounds per hour, the evaporation per pound of oil being approximately 16 pounds in the tests of lowest power and approximately 14 pounds in those of highest power. In all tests a surprisingly large percentage of the total work is done by the fire-box. This percentage is greatest when the rate of power is lowest. Speaking in general terms, at low rates of power from 45 to 50 percent of the total heat transmitted by the boiler is absorbed by the fire-box. With increase of power the percentage falls, but the lowest value thus far obtained is approximately 34 percent.

As the heating surface of the fire-box is a comparatively small fraction of the total heating surface of the boiler it is evident that heat is transmitted from the fire-box at rates which are extremely high. For example, results of a number of tests show the evaporation of more than 50 pounds of water per foot of fire-box heating surface per hour, which rate of evaporation is equivalent to the development of more than 300 horsepower by the fire-box alone. In estimating the significance of these results it should be remembered that in the experiments the fire-box virtually constituted a boiler by itself, that it had no more water about it than the normal locomotive fire-box, and that it could not benefit by the circulation of water from the forward end of the boiler backward into the water legs. The fact that fire-boxes subjected to such conditions could be worked at the rate of power stated is suggestive of new possibilities in boiler design. The full development of these data will make of record facts with reference to the distribution of work between the fire-box and tubes of a modern locomotive boiler which have never before been determined.

The experimental results have not yet been sufficiently studied to permit a final statement to be made concerning the relative performance of the radial-stay boiler and the Jacobs-Shupert boiler. It appears, however, that the absorption of heat by the Jacobs-Shupert fire-box is somewhat in excess of that absorbed by the radial-stay fire-box, and that taking the boilers as a whole the Jacobs-Shupert boiler is slightly more efficient.

TESTS WITH COAL

The oil-fired tests already described have been duplicated by a series of coal-fired tests. The results obtained, so far as they refer to the distribution of work between the fire-box and the tubes and to the relative performance of the radial-stay boiler and the Jacobs-Shupert boiler, are in entire agreement with those obtained from oil.

Boiler Explosions During 1911

The current issue of *The Locomotive* calls attention to the statistics concerning boiler explosions which occurred during 1911. Great care has been exercised in the compilation of the chronologically arranged lists, upon which the appended summary is based, and it is their belief that they have accounted for by far the greater number of boiler accidents which have taken place in the United States in the past year. As the accounts are received, and usually several newspaper clippings or letters reach us in regard to each explosion, they are carefully scrutinized and compared, so that the actual facts are determined as nearly as possible. The summary follows:

SUMMARY OF BOILER EXPLOSIONS FOR 1911.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January................	76	22	43	65
February...............	44	31	52	83
March..................	39	27	38	65
April..................	39	14	22	36
May....................	43	18	39	57
June...................	31	30	17	47
July...................	42	18	34	52
August.................	32	13	29	42
September..............	29	7	20	27
October................	48	14	53	67
November...............	39	11	35	46
December...............	37	17	34	51
Totals.............	499	222	416	638

Inspection of Locomotive Boilers

The first report of the chief inspector of locomotive boilers to the Government, which covers the period subsequent to July 1, 1911, shows that there has been a diminution in the number of casualties due to boiler accidents from 12 fatalities and 260 personal injuries during the three months immediately preceding the date on which the act became effective to 6 deaths and 32 personal injuries for the like period of three months immediately following the effective date of the act.—*From the Annual Report of the Inter-State Commerce Commission.*

Notice to Master Boiler Makers

The Secretary of the Master Boiler Makers' Association, Mr. Harry D. Vought, 95 Liberty street, New York, announces that the Proceedings of the Sixth Annual Convention, recently held in Pittsburg, will be ready for distribution on or before Aug. 1. As this issue of the Proceedings is limited all members of the association desiring extra copies must send in their orders at once.

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Members of the Master Boiler Makers' Association are to be congratulated upon the vigorous growth of that organization during the past year. The convention this year was a banner convention; all previous records of attendance and increase in membership were broken, and the proceedings at the convention indicate the vast amount of painstaking and conscientious work done by the individual members to bring about this success.

The method of selecting topics for discussion at the conventions and the progress of committee work on these subjects year after year are, on the whole, commendable; but there is still room for improvement in the committee work, as shown by the lack of reports on some of the most important subjects on the programme this year. It is not expected that the committee reports should assume the form of exhaustive scientific theses, but it is expected that they should provide a comprehensive report of practical experience gained from as many different points of view as possible. This is not a stupendous task for the committee men, and there is little excuse for neglecting the committee work altogether, as has been done in some cases.

In the discussions on the convention floor it is noticeable that the committee report itself is seldom referred to directly. The speakers, for the most part, confine their statements to their own experiences regarding the question, and there is no attempt to theorize or lay down hard-and-fast rules to guide future practice. In this attitude, in our opinion, lies much of the strength and vigor of the association. In almost every case there are so many qualifying conditions to be considered that variations in practice are inevitable, and to be thoroughly successful the practical man must know what others have done and what success they have had under various conditions. There is no other source from which such knowledge can be obtained more readily and more beneficially than from such meetings as are held by organizations of this kind, and for this reason all master boiler makers should become active members in this organization and have a part in its work.

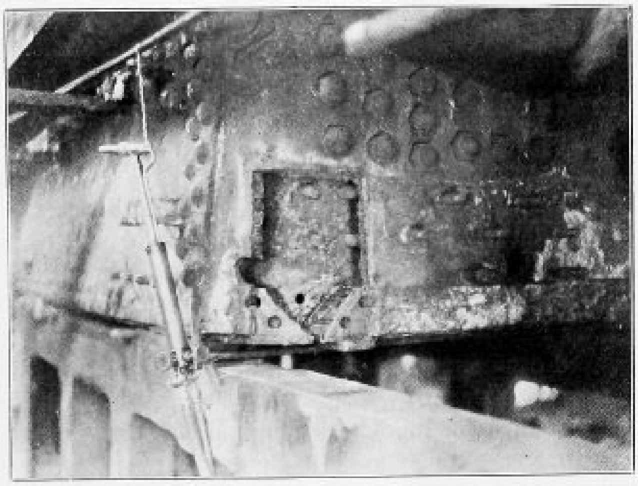
We call particular attention to the report of the Federal Locomotive Boiler Inspection Department regarding the San Antonio explosion, which is published in this issue. This report is very complete, and it is a good example of what this department can do in matters which have hitherto been neglected. After a searching investigation, the inspectors have gathered sufficient data and testimony to show the exact cause of the accident and the proper place to lay the blame for the explosion. In the first place, the construction of the boiler did not conform to the recognized standards, although it had been certified by inspectors that it did conform to such specifications. The crown bar sling stays were of wrought iron, whereas the specifications called for mild steel. One-inch bolts were used to attach the sling stays to the crown bars and wrapper sheets, where 1¼-inch bolts were specified. The crown bars were not supported on the sides of the firebox, so all the support was placed on the sling stays. Figures are given to show that the factor of safety of this part of the boiler under these conditions was between 2.67 and 3.26, whereas if the construction had complied to the required specifications the factor of safety would have been from 3.67 to 4.15. Further than that, the boiler was in incompetent hands when the explosion occurred, and the safety valves were being screwed down when there was no assurance that the steam gage was showing the actual pressure. There can be no mistake as to where the blame should be placed in a case like this. The railroad company was at fault in requiring or permitting inspections and reports to be made in a manner which was not in accordance with the law, and in allowing such important and responsible work as setting safety valves to be performed by an employee whose experience and judgment made him incompetent for the work, and the railroad company was at fault in keeping a boiler in service for which the factor of safety was below the recognized standard. If this boiler had conformed to the standards, and if the inspection had been properly done, the chance for this terrible disaster, resulting in the death of twenty-six and the injury of thirty-two others, would have been very remote. It seems that the time is ripe for exacting the extreme penalty of the law for such criminal negligence.

New Improved Engineering Specialties for Boiler-Making

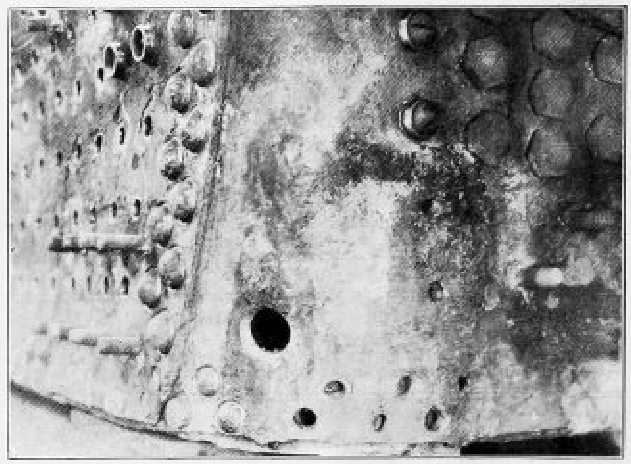
Demonstration of Oxy-Acetylene Welding and Cutting

The application of the oxy-acetylene welding and cutting blow-pipes to locomotive repairs was the subject of an interesting demonstration made during the sixth annual convention of the Master Boiler Makers' Association, held in Pittsburg May 14 to 17. The demonstration was made at the shops of the Pittsburg & Lake Erie Railroad at McKees Rocks, Pa., Thursday, May 16, under the auspices of the Oxweld Acetylene Company, New York, which has recently succeeded to the entire welding and cutting apparatus business of the Linde Air Products Company, of Buffalo.

About 110 of the delegates took advantage of the opportunity to witness this striking exhibition of some of the important pieces of work that are being accomplished daily by the oxy-acetylene process in many of the railroad shops of the country.



PATCH CUT OUT OF THROAT SHEET AND EDGES OF MUD RING BEVELED OFF PREPARATORY TO WELDING



FINISHED JOB, PATCH WELDED BACK INTO PLACE

Numerous examples of metal cutting with the blow-pipe were shown. Squares, straight lines and irregular shapes were cut in 3/8-inch plate. Pieces of steel 6 inches square were cut with ease. One piece, measuring 4 inches by 6, was cut with the oxy-acetylene flame in 37 seconds, according to time kept by one of the spectators.

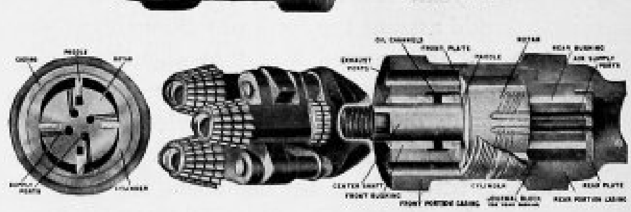
The possibilities of welding by this process were also fully demonstrated. A crack in a locomotive fire-box, 14 inches long by 3/4 inch wide, extending upwards from the mud-ring, was completely welded in 2 hours and 25 minutes at a cost, including all material and labor, of only $3.75. The position of a patch 14 inches wide by 24 inches high extending up from the mud-ring was shown. This patch was afterwards welded in 6 1/2 hours. Total cost, including labor and material, $9.50.

Previous to the visit of the members of the association, a cracked mud-ring measuring 4 by 4 1/4 inches was welded, as shown in the accompanying photographs. A patch 9 inches wide by 13 inches high by 1 1/16 inches thick was first cut out of the throat sheet in order to get at the mud-ring without removing it. The mud-ring was then beveled as shown, and the edges of the throat sheet and edges of the cut-out patch were also beveled, all of these operations being accomplished with the cutting blow-pipe. The mud-ring was then welded up and the patch welded back into its original position in the throat sheet, making the job complete. The time for cutting out the patch in the throat sheet was 15 minutes. The time for beveling the mud-ring 25 minutes. The time for welding mud-ring 4 hours. The entire cost of the operation, including oxygen at 2 cents per cubic foot and acetylene at 1 cent a cubic foot, Norway iron at 12 cents a pound and operator's time with helper at 50 cents an hour, was approximately $25.00. The great saving in time, labor and material effected by this process over other methods of welding can be readily appreciated from the above figures.

Many of the boiler makers were under the impression that overhead welding could not be accomplished, but the demonstrators proved that in this respect the oxy-acetylene process is thoroughly practicable and successful. A great deal of this kind of work has been done in the railroad shops.

A New Type of Air-Driven Boiler Tube Cleaner

The air or steam-driven type of boiler tube cleaner has been found the most satisfactory in many power plants because water is expensive or the pressure is too low to give sufficient power to drive a water turbine cleaner. Plants in which these conditions obtain will undoubtedly be interested in a new type of air or steam-driven cleaner recently perfected by the Lagonda Manufacturing Company, Springfield, Ohio. The



cross-sectional cuts of this cleaner, shown herewith, give a good idea as to its method of operation. As will be noted, the compressed air or steam passes through two ports in a plate in the rear end of the cleaner, then through transverse openings in the rotor, and out through branch openings to the space behind the paddles. There are only two ports opening into the air chamber, thus only the two paddles that are doing the work are under air pressure, and there is no communication to the two idle paddles, thus one of the main difficulties with other types of air-driven cleaners has been eliminated; that is, excessive leakage of air. After the air has done its work behind one of the paddles, the paddle uncovers an exhaust port, and the expanded air is allowed to pass out through the front end of the cleaner.

To permit the cleaner of operating economically under different air pressures and in different hardnesses or thickness of scale, two interchangeable rear plates are provided having different size port areas. Where there is a limited amount of air available the plate with the smaller holes can be used, thus insuring plenty of power with small amount of air. If the scale is heavy and plenty of air can be furnished the plate with larger holes can then be used and more power developed. The cleaner is furnished with either the Weinland quick repair head, or with other types manufactured by this company, and is built for cleaning tubes of 1 to 4 inches in diameter, and a special design is suitable for use in curved tubes.

The Prest-O-Welder

Welding by means of the oxy-acetylene process has firmly established itself as an important factor in the manufacture of machinery and metalware and in the reclaiming of broken castings, whether of cast iron, steel, brass, bronze or aluminum.

The Prest-O-Welder, manufactured by the Prest-O-Lite Company, Indianapolis, Ind., is a practical adaptation of this successful process to the needs of the average shop. Storage tanks of 100 cubic feet capacity are furnished for each of the gases used. This, it is claimed, eliminates the inconvenient features of the generating systems and insures safety. A supply of pure dry gas is always ready for service upon opening the valves. The whole equipment is mounted on a small steel truck, which makes the Prest-O-Welder a portable and convenient equipment for all uses. The weight of the equipment completely assembled is 300 pounds.

Welding by the oxy-acetylene process utilizes in a small, concentrated flame the heat produced by the combustion of acetylene and oxygen. The intense heat and concentration allow the recasting of the metal in the joint to be welded. As the flame is neutral the welded metal does not suffer any injurious effects. A temperature of 6,300 degrees F. is obtained. This temperature, while more than double that required to melt any of the commercial metals, is necessary for successful welding on account of the rapid dissipation of the heat through the metal, especially where heavy material is being welded. The combustion of acetylene not only produces an extremely high temperature but also furnishes an enormous amount of heat, making possible the successful welding of the heavy materials.

The essential features of the Prest-O-Welder are an acetylene and oxygen tank, each with proper automatic reducing valves attached. The acetylene is stored in a cold-drawn, seamless steel tank, having a capacity of 100 cubic feet, and is known as dissolved acetylene, *i. e.*, acetylene dissolved in acetone in a porous filling inside the tank. The oxygen, which is to support the combustion of the acetylene, and intensify its heating power, is stored in a steel cylinder of 100 cubic feet capacity. The acetylene is led through a regulating valve, which automatically maintains a constant flow of gas. The oxygen is also controlled by a regulating valve, which can be instantly set to deliver the required amount of oxygen for the flame desired. The two gases are united in the mixing chamber of the blow-pipe. The welding heads on the blow-pipe are interchangeable and easily adapted for different sizes of material and castings.

The outfit is always ready for instant use. It needs no further attention than merely opening two valves when required. When not in use no valuable space is taken up, because the outfit is compact and easily moved about. The operation of the Prest-O-Welder is not difficult, and it is said that the ordinary workman soon becomes proficient in all its uses.

No. 50 Boyer Hammer with Reversed Handle

The Chicago Pneumatic Tool Company, Chicago, Ill., has placed on the market a pneumatic riveting hammer for getting into close quarters where the ordinary riveting hammer would be too long or where it could not be conveniently handled. It has a piston 1 1/16 inch diameter by 5-inch stroke; will drive ⅞-inch rivets in structural work and ¾-inch in steam-

tight boiler work, and is 14 inches over all, including rivet set. It is particularly well adapted for driving the rivets in firebox doors where the space is limited to about 14½ inches. In structural work this hammer is useful where the box type of girder is used.

Communications of Interest from Practical Boiler Makers

Piece Work

I would like to say a few words for the benefit of Mr. Hartley, who in his article in your May number favors piece work, and for the benefit of others who advocate the piece-work system. An employer using the piece-work system is looking for quantity, for he cannot get the quality, and as for doing away with labor troubles I wish to say it is the cause of most of the trouble in the country to-day and is opposed by organized labor. I can say from experience in one of the largest shipyards in this country, where the day-work system was used, the work turned out was the *best,* but when the piece work was started the mechanic was compelled to slight his work to get enough done to make big pay, and with the inspectors I have seen it is easy to get a job passed. So give us day work and honest pay, and we will give a good job; if we don't, fire us, but don't say piece work. SUBSCRIBER.

Applying Patches to Locomotive Fire-Boxes

The question has been asked, "What are the best methods of applying patches to locomotive fire-boxes?" This has been the problem that has confronted the motive power department of all railroads since the invention of the locomotive; still there is no solution of the problem. True, patches are being welded on to all parts of fire-boxes with reasonably good results, but the system is still in its infancy, and has yet to stand the test of time before it will be generally adopted.

To put a patch on a fire-box there is no material difference in its application according to the location the patch may occupy, but there is a difference in the patch itself, for on many roads the box patch is used exclusively on side sheets; if the box patch is used on or near the mud-ring then the bottom of the patch must be made taper so that the grate-bar rests can be removed at any time, but as there are many boiler makers who have never seen or made a box patch I will deal with the plain flat patch. The material to be used should be of the very best fire-box steel (or if the box is a copper one the patch should be of copper also), of the same thickness as the old box.

Having located and removed the defective portion of sheet, being careful that all corners are cut round, thus avoiding the possibility of forming a crack, carefully remove the sharp edges left by the gouge. While cutting out the bad spot remove all iron scale left on the sheet that will be the new lap; get out the patch and pitch the holes 1⅞ inches apart, using ¾-inch patch bolts. *Drill* and countersink all holes, so that the threaded end of the bolt clears the holes and the head fits the countersink neatly and flush. Having put in your stay-bolt holes you are now ready to apply the patch, which can be easily done by bolting through the stay-bolt holes; draw your patch up tight, so that it will not move. Then through the holes in the patch carefully center and drill the new holes 21/32 inch. After this operation remove the patch; clean off all drill cuttings; replace the patch with ⅝-inch fitting-up bolts through the holes in the lap, getting in as many as possible to make good, close work. While tapping your holes keep your tap perfectly straight, so that it conforms to the contour of the side sheet. If this is properly done your bolts should find a proper seat in the countersink. Work your patch up good, either with the pean end of your chipping hammer or a drift pin, slightly rounded on the end; after each hammering tighten up the patch bolts until the shanks break off, which they should do if they have been turned down to 9/16 inch close to the head. Then with a rough rivet tool or frenchman work the head of the bolt down until the bolt and patch appear to be one piece, then with a smooth frenchman or rivet tool remove all the marks made by the wrought tool, at the same time calking the head in the usual way. If you are to apply the patch with rivets, use ¾-inch rivets, pitched 2⅛ inches apart, or as near as circumstances will allow. I have used fillers of copper, galvanized, and other soft iron, white lead and different compounds, but never found any advantage in their use. My rule in patching has always been *drilled* holes, close laps; avoid the use of the drift pin, and for any bad holes that may possibly occur use the half-moon reamer. During the last thirty-two years I have found that punched holes form cracks that cannot be seen with the naked eye, and the use of the drift pin opens them up, hence the so-called fire cracks we so frequently see in the fire-boxes to-day. G. H. HARRISON.

Pittsburg, Pa.

Further Comments on the A. B. M. A.

Your valuable journal, May number, contained a very interesting "Comment on the A. B. M. A.," signed "Progressive." The comment is especially interesting to the Supplymen's Association of the American Boiler Manufacturers' Association, because we undertook to sufficiently interest the boiler manufacturers and the various supplymen, jobbers and tool manufacturers of the United States and Canada to attend the twenty-fourth annual convention at New Orleans, March 12 to 15, 1912. And with what result?

As the convention was scheduled for March 12 to 15 a campaign of action was planned previous to Jan. 1, and directly thereafter a systematic correspondence was inaugurated with the editors of twenty-seven of the leading technical and trade journals of the United States and Canada, asking their co-operation by giving full publicity to our appeal to boiler, tank and stack manufacturers of the United States and Canada to attend the convention in New Orleans.

In addition to publishing our letters the editors of these publications wrote masterful editorials urging the co-operation of manufacturers in this and kindred lines to attend the convention and give the A. B. M. A. their unbounded support. The editors of these trade publications were not slow to recognize the advisability of our adopting uniform and standard specifications, and they very generously put the matter before their readers.

In addition to the above newspaper publicity we sent out letters and notices to every one of the 1,000 boiler, tank and stack manufacturers, asking them to attend the convention, *whether members or not,* and thus assist the A. B. M. A. and give support to same, if only by their presence.

It was fully realized that the expense of going to New Orleans from Canada and remote places in the United States would put a tax upon the individual manufacturer, and to overcome this letters were written to different parts of the country, suggesting that the boiler manufacturers get together in a local meeting and appoint one or more delegates to attend the convention and levying an assessment toward defraying the expenses of the delegate, which could have been accomplished at a nominal expense to the several shops in a community, but in no single instance was this suggestion adopted.

The Supplymen's Association believe if boiler manufacturers can be made to fully understand that by attending the A. B. M. A. conventions, and by personal contact with their fellow manufacturers, they will gradually become less suspicious and antagonistic toward their competitors, and the general business will improve in a marked degree.

A farmer with whom the subscriber was acquainted with some years ago could not be convinced that the world was round, and laughed to scorn any attempts to prove that it was. Now, stop and think, Mr. Boiler Manufacturer, was the poor farmer really to blame? He only saw the world from the confines of his farm.

This same condition exists with members of our profession. "A" says he hates "B" because he is a price cutter, and in turn "B" hates "A" quite as cordially, saying that "A" uses inferior material and does poor work, all of this to the delight of the gentlemanly purchasing agent, who pits one against the other, and usually buys his product at or near cost, thus increasing the enmity between "A" and "B."

This condition of affairs can be and will be stopped if each and every one of you will break over the "stay-at-home," "world-is-not-round" principles and go to the A. B. M. A. conventions, meet your competitors like men, and you will find a lot of good, bright timber among them that you have hitherto shunned.

Confidence is the foundation upon which our government and all good business enterprises are based, and to establish confidence and a friendly feeling among men is to be well and favorably known. This is best accomplished by personal contact and a hearty handshake.

In conclusion I would say to the writer of the article signed "Progressive" in your May issue: We feel like you that it is time to get action upon the delinquents, and as the snowball develops into an avalanche we hope others will take up the good work and enlighten us with their views, using the columns of THE BOILER MAKER to show us whether we are right or wrong; and if we are right in our views and statements, let us see at least 500 boiler manufacturers in Cleveland at the twenty-fifth annual, or silver anniversary, of the A. B. M. A., to be held about a year hence.

I should like to hear from the regular attendants at our convention as to what advantages they derive from attending these conventions, which would undoubtedly be a convincing argument in showing what manufacturers lose by not attending.

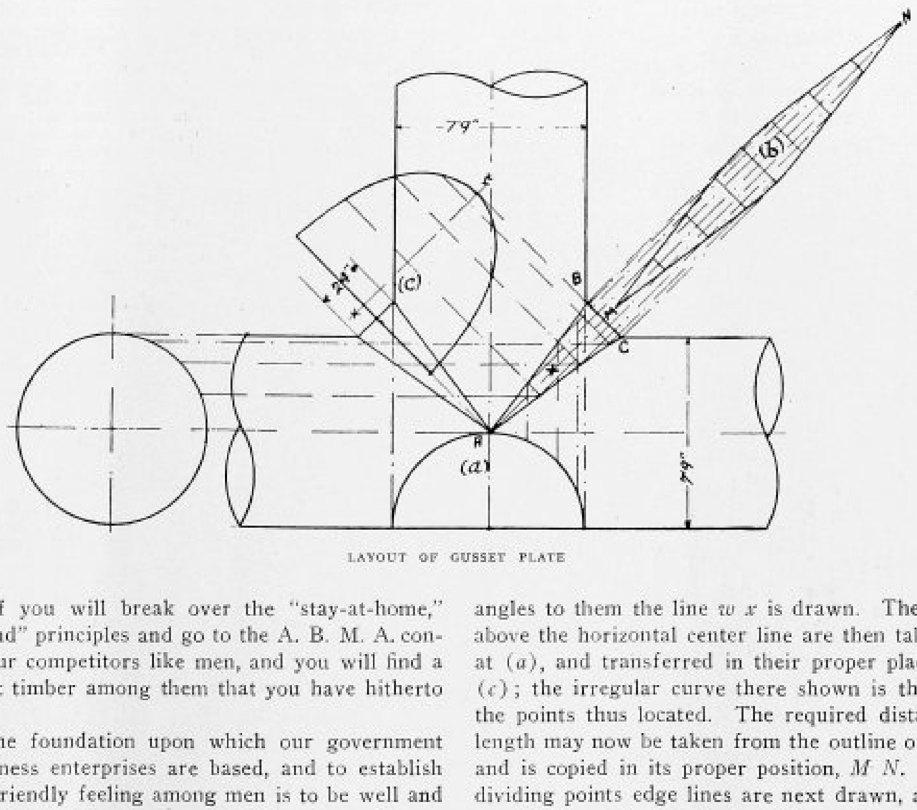
F. B. SLOCUM,
Secretary, Supplymen's Asociation of the A. B. M. A.
Brooklyn, N. Y.

Layout of Gusset Plates

Referring to the May issue of THE BOILER MAKER, regarding the problem which has puzzled one of the readers, I wish to call attention to the following method which I use in laying out such problems:

Draw first the elevation, then with a 45 degree angle draw *B C* the required length, 24 inches; then *A B* from the middle point of the intersection shown in the elevation. The method of development is to draw vertical projectors from the end view of the stack at (*a*), producing them until they intersect the line *A. B;* thence they are continued parallel to *B C*, and intersected in the lower portion of the drawing of the gusset plate by the horizontal projectors drawn from the end elevation in the manner shown in the drawing.

To determine the exact length of this pattern a section at right angles to the parallel lines of the gusset plate must now be drawn. The assumed edges are accordingly produced indefinitely toward the left side of the drawing, and at right angles to them the line *w x* is drawn. The vertical distances above the horizontal center line are then taken from the view at (*a*), and transferred in their proper places to the view at (*c*); the irregular curve there shown is then traced through the points thus located. The required distances for the true length may now be taken from the outline of the curve at (*c*), and is copied in its proper position, *M N*. Through its subdividing points edge lines are next drawn, and developers are carried from the required points on the outline of the gusset plate. The resulting pattern at (*b*) will therefore be the required outline, and, if desired, edges may be added for riveting flanges.



LAYOUT OF GUSSET PLATE

JOHN A. CLAS.
Albany, N. Y.

Personal

C. HOBBS, foreman boiler maker, Ann Arbor Railroad, Owosso, Mich., was recently promoted to general foreman, locomotive department, headquarters, Owosso.

JOHN TROY, for many years foreman boiler maker of the Pere Marquette Railroad, Saginaw, Mich., has succeeded Mr. C. Hobbs as foreman boiler maker at Owosso, Mich.

E. C. UNSLAUF has been appointed foreman boiler maker of the Delaware, Lackawanna & Western shops at East Buffalo, N. Y., vice Mr. Joseph McAllister, resigned, to accept position as United States inspector of locomotive boilers for the Inter-State Commerce Commission.

FRANK J. STARAL has resigned his position as foreman and layerout with the Chicago Boiler Company, and has accepted a position with J. T. Ryerson & Sons in their plate department.

OWEN E. ROONEY, assistant foreman boiler maker for the Kelly Springfield Road Roller Company, Springfield, Ohio, has resigned his position. Mr. Rooney was with this company about two years. Previously he was at Elmira, N. Y., employed as foreman boiler maker for the American Steam Fire Engine Company. After his resignation Mr. Rooney returned to his old home at Seneca Falls, N. Y., for a rest and with the intention to return to business on June 1.

A. J. WILLIAMS, first vice-president of the Parkesburg Iron Company, Parkesburg, Pa., died on Saturday, May 25, at Parkesburg.

Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

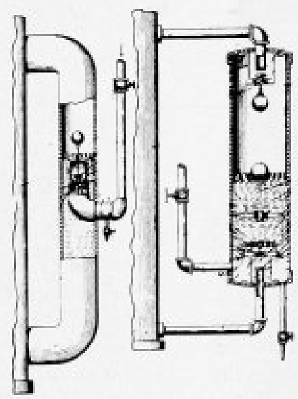
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,012,074. DUMPING-BOTTOM FOR ASH-PANS OF LOCOMOTIVES. OSCAR GOLDEN, OF EL PASO, TEX.

Claim 3.—In an ash-pan having rocking floor sections, the combination with the floor sections; of cross pieces at the ends thereof adjoining the sides of the ash-pan to take up wear and make a tight fit, and shafts extending the full length of the floor sections, attached to the floor sections through said cross pieces and having at the ends a series of rocking devices all connected for simultaneous operation. Three claims.

1,013,462. AUTOMATIC CUT-OFF FOR BOILER FEEDERS. CHARLES C. TOZIER, OF SKOWHEGAN, MAINE.

Claim 1.—In an automatic boiler feeder cut-off, a receptacle having



connections at its opposite ends with a boiler, a source of supply to said receptacle, a vertically floatable valve controlling the outflow from said receptacle and a float and connections within said receptacle for controlling said valve. Seven claims.

1,014,573. COMBINED SMOKE CONSUMER AND VAPORIZER. OTHMAN DAVIS, OF GAINESVILLE, TEX.

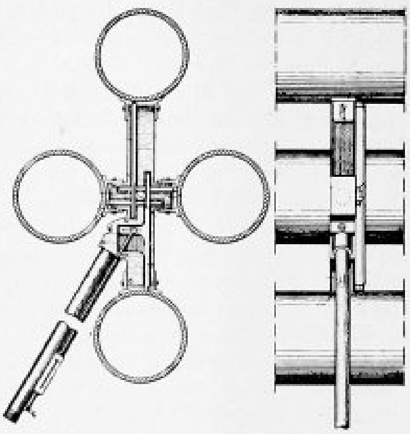
Claim 1.—In apparatus, a furnace structure, including a stack, fire box and ash pit, apparatus to draw the products of combustion from the stack and introduce the same into the ash pit, a device for holding liquid fuel to be gasified, means for conducting a portion of the products of combustion circulating in the apparatus into proximity to said device for heating the same, and means for conducting the vaporized fuel into the fire-box. Four claims.

1,014,530. SUPERHEATER. HUNTER SMITH, OF BERKELEY, CAL., ASSIGNOR OF TWO-THIRDS TO FRANK D. CHASE, OF BERKELEY, CAL.

Claim 1.—In a steam superheater for boilers, a column consisting of a boilertube, a header at each end of the tube, a casing built up of metal rings inclosing said tube, a shaft in said tube extending from end to end thereof, and a spiral flange extending from end to end of said shaft, said shaft and spiral flange being formed in sections. Three claims.

1,014,459. TOOL FOR SPREADING BOILERTUBES. AUGUST P. GERALD, OF JERSEY CITY, N. J.

Claim 1.—A tool, comprising a body portion provided with vertically and horizontally-aranged cylinder bores, all having their axes lying in the same vertical plane, a piston fitted to slide in each of said cylinder bores and having its outter face adapted to engage with a boiler-tube, means for delivering fluid under pressure to each of said cylinder



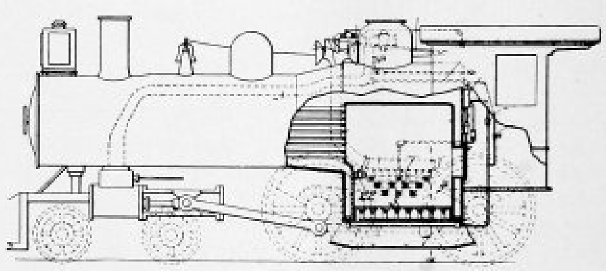
bores, and means connecting all of said pistons to insure their simultaneous movement. Four claims.

1,014,456. MEANS FOR PROTECTING WATER-GAGE TUBES OF STEAM BOILERS. GASTON ERNEST EDOUARD DEGEORGIS, OF ST.-DENIS, SEINE, FRANCE.

Claim 1.—A protector for water gages of steam boilers, comprising a metal envelop formed of two members hinged together, and each provided with an opening, means for holding the members closed, a frame detachably secured to each member over the opening thereof, and a glass carried by each frame. Two claims.

1,014,387. SMOKE AND GAS CONSUMER FOR LOCOMOTIVES. DANIEL GOFF, OF MILLVILLE, N. J., ASSIGNOR TO GOFF GRAVITY BOILER FEED COMPANY, OF CAMDEN, N. J., A CORPORATION OF NEW JERSEY.

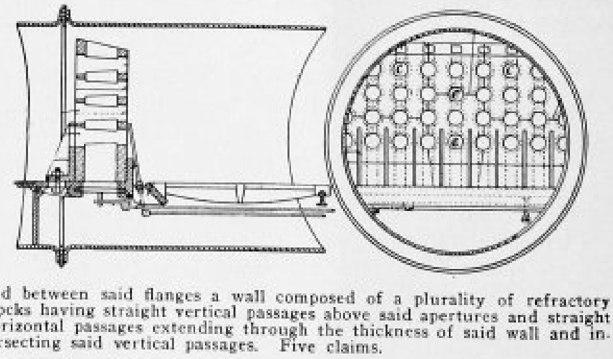
Claim 2.—In a device, a locomotive boiler, a fire-box therefor, a suitable grate, a plurality of air inlets above said grate at each side of said fire-box, an air conduit communicating with each series of air inlets, a plurality of collectors secured to each conduit, means to control the passage of air through each collector, a steam nozzle connected to each



air inlet and adapted to discharge steam into each inlet, a box transversely disposed in said fire-box having a series of steam discharge openings, a steam supply connected to said steam openings, a furnace door, and means controlled by the movement of said door for regulating the flow of steam through said box. Three claims.

1,014,377. FIRE BRIDGE. WILLIAM EDWARD CURRAN, OF CARDIFF, ENGLAND.

Claim 1.—In a furnace fire bridge, a base-plate having apertures, a fixed flange on said base-plate, an adjustable flange on said base-plate



and between said flanges a wall composed of a plurality of refractory blocks having straight vertical passages above said apertures and straight horizontal passages extending through the thickness of said wall and intersecting said vertical passages. Five claims.

1,013,887. DEVICE FOR CREATING A DRAFT THROUGH SMOKESTACKS. JAMES DONNELLY McKAY, OF ST. JOHN, NEW BRUNSWICK, CANADA, ASSIGNOR OF ONE-HALF TO JARVIS CARRY PURDY, OF ST. JOHN, CANADA.

Claim 1.—The combination with a smoke pipe, of a partially cylindrical shell surrounding the same, supporting members on the shell adapted to extend over the top of the smoke pipe by which the shell is supported on the exterior below the top of the pipe and deflecting wings within the shell spacing the same from the pipe and adapted to deflect the air upwardly. Three claims.

THE BOILER MAKER

JULY, 1912

Hydraulic Press Dies

BY J. H. NASH *

Pressure exerted upon a liquid enclosed in a vessel is transmitted undiminished in every direction. This conclusion of the transmission of pressure by liquids was first stated by the French scientist. Pascal, and is known as Pascal's Law. The hydraulic press is a machine which is based on Pascal's Law, and is one of the machines used to form various boiler sheets. The following description is based on a hydraulic press and dies used at the Burnside shops of the Illinois Central Railroad Company.

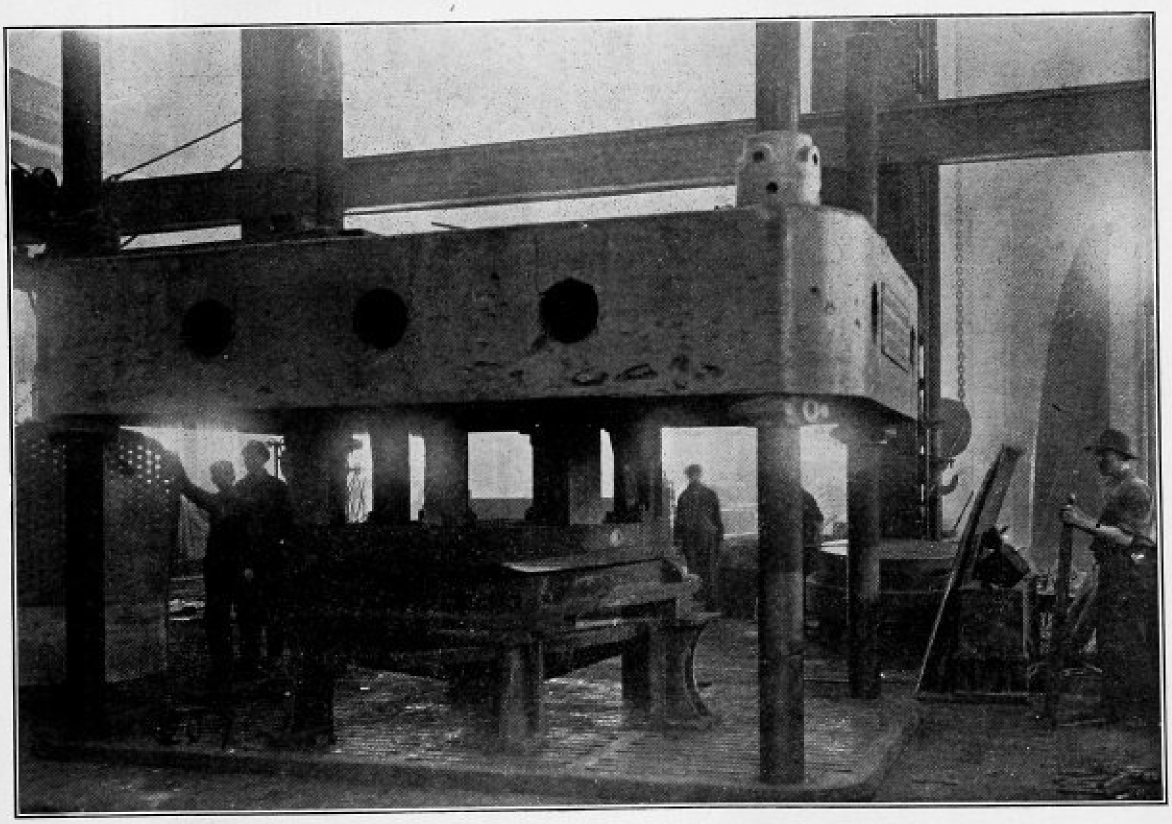


FIG. 1.—HYDRAULIC PRESS USED AT THE BURNSIDE SHOPS, ILLINOIS CENTRAL RAILROAD

Fig. 2 illustrates the mechanism of the press and machinery for operating same. The pump shown supplies all the hydraulic machinery in the boiler shop.

The water passes from the pump through a 2-inch pipe to an accumulator. The object of an accumulator is to keep the pressure in the mains the same when the amount drawn from the mains exceeds the output of the pump. The accumulator is a cylindrical tank 9 feet in diameter and 15 feet high, open at the top and filled with rivet punches, etc. In the center of the tank, extending from top to bottom, is a cylinder, which is closed at the top. Inside of the cylinder is a hollow piston extending from the floor to the top of the cylinder when the accumulator is down. The outside diameter of the piston is 14 inches. The water from the pump passes through the bottom of the piston into the supply pipe of the shop. When the supply pipe is filled the water rises in the piston, pressing against the top of the cylinder and forcing the accumulator up, which, in turn, when it reaches a certain height, strikes a trip which stops the pump. The accumulator weighs 150 tons, making a pressure of 1,948 pounds per square inch in the supply pipes. Between the pump and the accumulator is a check valve to stop the water from backing up.

Leading from the supply pipe to the press are two pipes; one is a 1½-inch and the other a 2½-inch pipe. These pipes lead into triple valves, one independent of the other, which are controlled by levers. These valves have three openings; one is the in-take, another leads to the cylinders of the press

* Shop superintendent, Burnside shops, Illinois Central Railroad.

and the other is the outlet which leads to the sewer. When the in-take is open the outlet is closed and *vice versa*. Leading from the 2½-inch valve is a 2½-inch pipe which leads into the main cylinder of the press. Inside of the cylinder is a piston 30 inches in diameter, which controls the elevating table. The total pressure against the piston amounts to 689½ tons theoretically. When the lever controlling the valve is

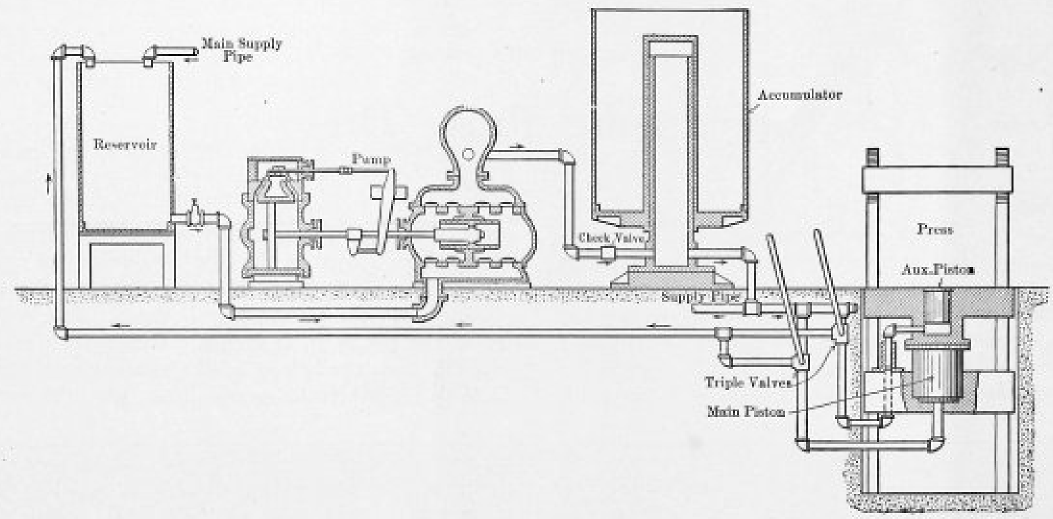


FIG. 2.—DIAGRAM ILLUSTRATING THE OPERATION OF THE PRESS

thrown over the in-take is opened, allowing the water to pass through into the pipe which leads into the main cylinder. The pressure against the piston raises the table. Reversing the lever closes the in-take and opens the outlet, allowing the water to pass into the sewer. From the sewer the water passes into a reservoir which is connected with the pump.

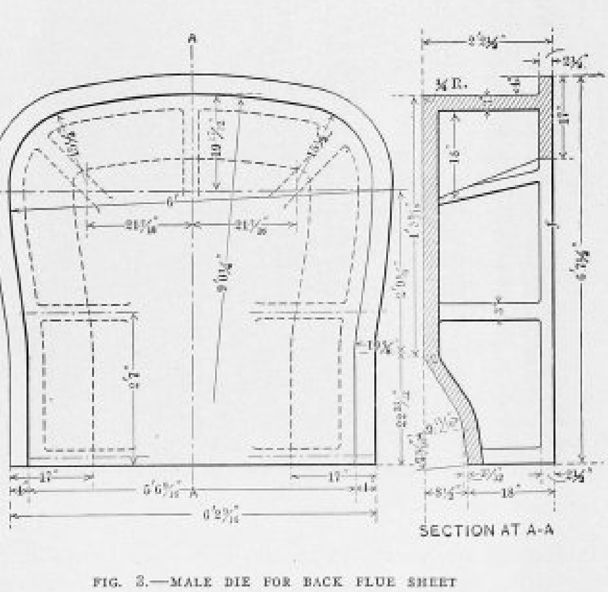


FIG. 3.—MALE DIE FOR BACK FLUE SHEET

The reservoir is 4½ feet in diameter and 8 feet high, having a capacity of 958 gallons.

In the center of the elevating table of the press is a cylinder in which the auxiliary piston works. The piston is 14 inches in diameter, making a total pressure of 150 tons against it theoretically. This piston is controlled by the 1½-inch valve, and the operation is the same as the main piston.

In order that the pistons can be operated independent of one another, a slip joint is used in the piping of the auxiliary piston, which consists of the feed pipe fitting inside of a cylinder so that the pipe will raise or lower to suit conditions.

Fig. 1 shows a hydraulic press with dies set for pressing a back flue sheet of a locomotive boiler. There are three dies used in this process—a male, female and clamp, which are made of cast iron. The male and female dies are fastened to the top of the press and the elevating table, respectively, by means of pedestals and bolts. The clamp die is placed on the auxiliary piston.

A furnace, for heating the material, is placed near and in a convenient place with a crane and other appliances for handling material. When the sheet is heated to an orange color it is placed on the clamp die and set in position. The

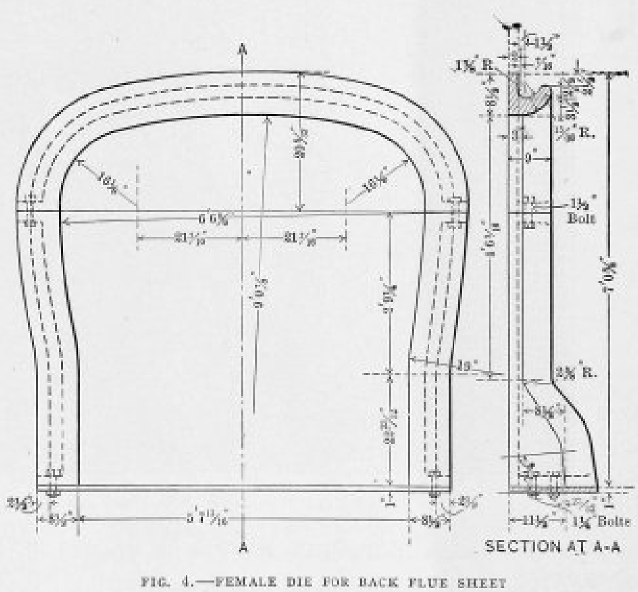


FIG. 4.—FEMALE DIE FOR BACK FLUE SHEET

operator then pushes the lever controlling the auxiliary piston, which brings the sheet up against the male die holding the sheet fast. The lever controlling the main piston is pushed over, which raises the table and female die. The female die passes up around the male die, bending the sheet into its required shape. The operation is reversed and the sheet is removed.

Figs. 3, 4 and 5 are drawings of a male, female and clamp die, respectively, for a back flue sheet of a locomotive boiler.

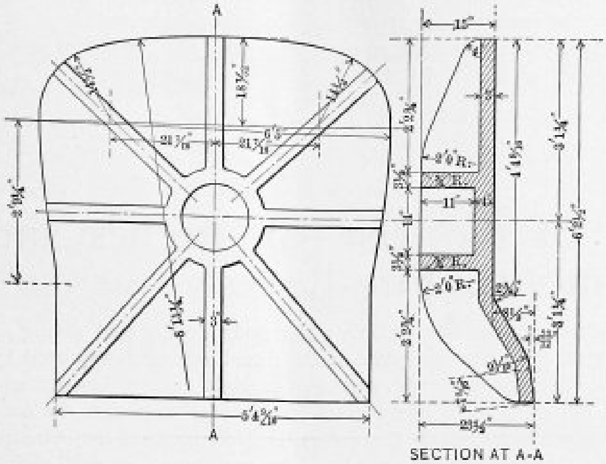


FIG. 5.—CLAMP DIE FOR BACK FLUE SHEET

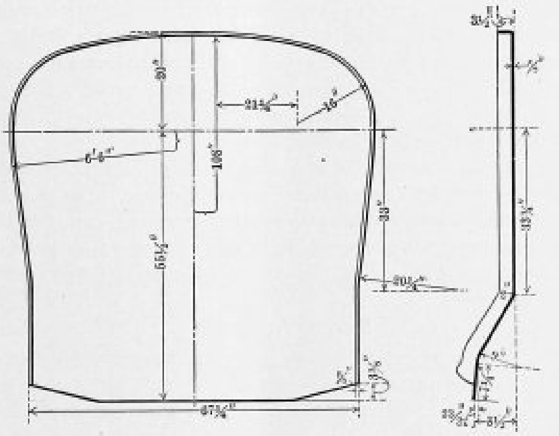


FIG. 6.—FLUE SHEET MADE FROM DIES SHOWN IN FIGS. 3, 4 AND 5

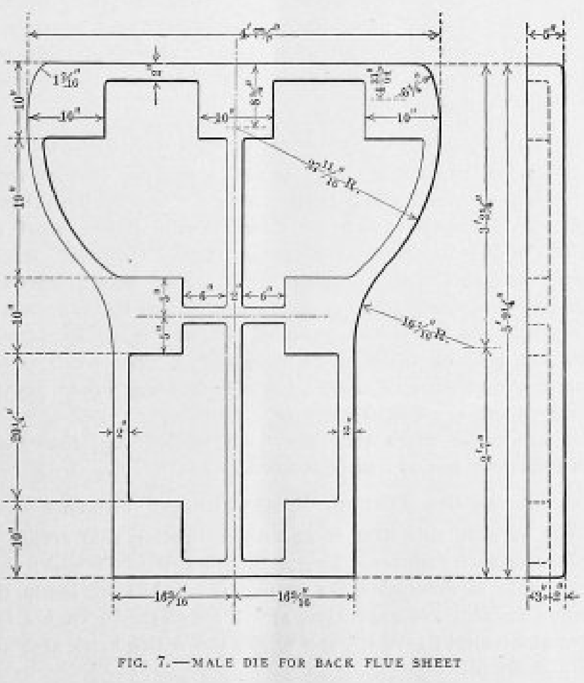


FIG. 7.—MALE DIE FOR BACK FLUE SHEET

The male die forms the inside of the sheet and the female die forms the outside of the flanges of the sheet. The clamp die is used to hold the sheet against the male die and also forms the face of the sheet. The outline of this die is made 1 inch smaller than the male die.

Fig. 6 is a drawing of the flue sheet pressed by dies shown in Figs. 3, 4 and 5. It will be noted that the general outline of the flue sheet is smaller than the outline of the dies. This is due to the shrinkage of the sheet when cooling off, and this must be taken into consideration when designing dies. For soft steel plates, one-eighth of an inch to every 15 inches is allowed for shrinkage.

In designing dies for this work it is customary to make the

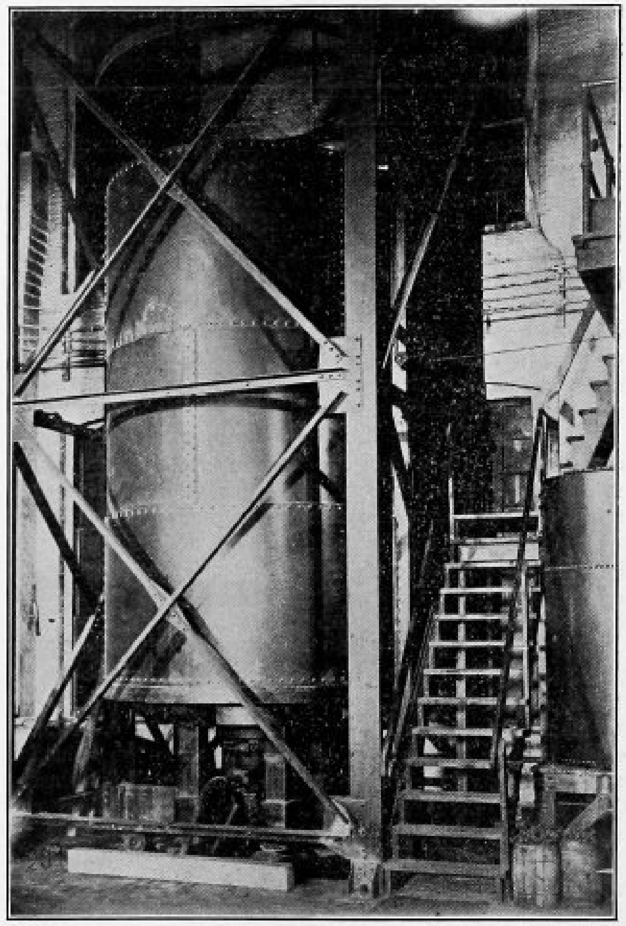


FIG. 8.—ACCUMULATOR

thickness of metal from 2 to 3 inches for large work and 1½ to 2 inches for small work. Owing to some dies being very heavy and clumsy if made in one piece, it is policy to make them in sections and bolt together with 1½-inch bolts, as shown in Fig. 4.

Fig. 7 is a male die for another locomotive boiler flue sheet. You will notice that this die is much smaller in depth than the one shown on Fig. 3, being only 5 inches. The difference in depth is taken up by means of pedestals, as shown on Fig. 1, which makes it possible to reduce the weight and size of the die and makes it more easily handled.

Fig. 8 shows the accumulator, at the right of which is shown a portion of the reservoir.

Besides pressing flue sheets this press is used for various other things. Smoke-box covers and doors, fire-box and boiler heads, cylinder head covers, lacing for ash-pans, side stakes for steel gondola cars, heads for reservoirs and tanks, steam-chest cover casings, step boxes, headlight brackets, pilot nose irons for suburban engine, wheel covers for ash-pans and refrigerator ice pans, are a few things which are formed by the press.

Cutting channels cold is another feature. Channels removed from old car trucks are cut in pieces by means of dies and used for reinforcements on trucks, etc., which makes a saving of about one dollar on every channel.

Advantages and Disadvantages of the Use of Arches and Arch Pipes in Locomotive Fire-Boxes*

After recapitulating the previous work on this subject by the association the committee sent letters of inquiry containing twenty-eight questions on all phases of the subject to all of the members of the association that were registered as being employees of railroads. These letters of inquiry brought about eighty replies covering some thirty railroads. Of the eighty replies, thirty members begged to be excused from answering questions, due to the fact that they had no experience or knowledge of the subject that would be of any information; fifty members filled out the inquiry blank to the best of their knowledge, and these fifty replies cover a great many years of experience on thirty of our leading railroads.

These reports have been tabulated. It has been our endeavor to put this vast amount of valuable information in the best form possible to obtain a clear conception of the facts. At the top of the chart we have put in a recapitulation in order to have a composite of all the replies.

It has been the endeavor of your committee to determine as accurately as possible what the advantages of the brick arches are and as far as possible the true value of these advantages. It has also been our endeavor to determine definitely the disadvantages of the arch and arch pipes and, as far as possible, the actual cost to the railroad companies of these disadvantages. The difference then between these two quantities we hope to show as net result.

Under the caption "Advantages" are the following items: 1, coal saving; 2, smoke abatement; 3, flue protection or reduction in roundhouse flue work; 4 improvement of steaming qualities under demands for maximum power; 5, reduction of engine failures from leaky flues and low steam; 6, reduction in flue stoppages; 7, reduction in honey-combing of flue sheets; 8, beneficial effect of the arch tubes on circulation and evaporation; 9, effect on life of set of flues.

On the side of "Disadvantages" may be listed the following: A, cost of maintenance of the brick; M,. cost of maintenance of arch pipes; C, detrimental effect, if any, on fire-boxes; D, delays, if any, to the turning of power at the roundhouse due to the presence of the arch in the fire-box.

Referring now to the recapitulation at the top of the chart.

Coal Saving

We find that the replies are almost unanimous in stating there is a coal saving, the average of the percentage given being 11.9 percent. It is an interesting fact that this percentage virtually checks or verifies the result of a very comprehensive test recently made to determine the coal saving of the arch. The test referred to is the one conducted by a committee made up from men of the Pennsylvania Railroad Company, the New York Central Railway Company and the American Locomotive Company on a Mallet engine on the Pennsylvania division of the New York Central Railway. The conclusions of this committee were to the effect that the brick arch under the conditions tested gives a fuel saving of 11 percent. (The result of this particular test is not included in the above chart.) We have also information on other very well-conducted tests which would indicate the coal saving of 12 percent or more. We find the coal saving as reported by the different members varying from slight saving to 25 percent. This might seem inconsistent but for the fact that the conditions under which these various percentages were obtained are evidently quite variable. The percentage of coal saving varies largely with different degrees of intensity of the work. For very light work the percentage of coal saving will be slight. For very high rates of work, or rather high rates of combustion, the percentage should be high. Again, when the coal is of a low volatile nature the effect of the brick arch on coal saving will not be so high, but with high volatile coal there is much for a brick arch to do, and under such conditions will show a high percentage of fuel saving. The committee feels that 11.9 percent may be considered a fair figure for the average conditions.

Assuming a locomotive working 330 days in a year, making 100 miles per day, and making on an average of 20 miles per ton of coal, the tons of coal consumed per year are 1,650 tons; 11.9 percent of 1,650 tons is 196 tons; money value at $1.00 a ton would be $195, at $2.00 per ton, $382, and at $3.00 per ton $588 per year.

Smoke Abatement

The composite report shows up quite favorably for the arch from a smoke abatement standpoint, average being 40 percent. This again depends upon the nature of the coal used.

Effect on Flue Work and Percentage of Reduction of Frequency of Calking

Under this we find that thirty-five report reduction in flue troubles, two find additional flue troubles, while three report no effect, a very large majority reporting favorably on this item. The average percentage of reduction in frequency of calking is 40 percent. Just what money value this would represent we are not able to determine at this time, but it would no doubt be considerable.

Effect on Steaming Qualities Under Maximum Demand

Forty-five replies say that arches make the engines more consistent steamers; one reply states no effect. This would indicate that arches were of decided value. Just what the money value would be we cannot state. However, it certainly indicates that by using brick arches better schedules can be maintained, a thing very important to the railroads in competing for high-class business. It may mean less double heading, a thing much to be desired. A very small reduction in the number of cases of double heading would pay for much of the brick arch expense.

It can mean more tons per train hauled, and thus more ton miles per ton of coal consumed.

Do Arches Tend to Reduce Engine Failures?

The vote on this item is 42 to 5, indicating that arches do reduce engine failures. This is another item in which it is impossible to determine the money value, but we know that engine failures are expensive, and a reduction in engine failures alone might save enough to pay the entire brick arch cost of a railroad.

* From a committee report (George Wagstaff, chairman) presented before the Master Boiler Makers' Association, Pittsburg, May, 1912.

DO ARCHES REDUCE FLUE STOPPAGE?

The vote on this item is 37 to 10 favoring the arch. Money value not determined.

EFFECT, IF ANY, ON HONEY-COMBING OF FLUE SHEETS

The vote on this is 29 to 9 in favor of the arch. No attempt to express this in dollars and cents.

EFFECT OF ARCH PIPES ON BOILER EFFICIENCY, CIRCULATION AND EVAPORATION

Replies indicate 23 favorable to 2 neutral on these points. A previous report to the association shows a fraction over 1 percent gain of efficiency per arch pipe. This gain would more than pay arch pipe maintenance cost.

EFFECT ON LIFE OF SET OF FLUES

Thirty-two replies say life of flues is increased, two say the life is decreased and four say no effect, a very large majority finding that the arch is beneficial in this respect. Money value of this item is not determined.

As against the above advantages we have the possible disadvantages as follows:

ADVANTAGES AND DISADVANTAGES OF THE USE OF BRICK ARCHES AND ARCH PIPES IN LOCOMOTIVE FIRE BOXES.

"REPORTS AND RECAPITULATION OF SAME FROM 50 MEMBERS REPRESENTING 30 LEADING RAILROADS"

	SAVES COAL—11 YES-39 NO-1 AV.=11.9%	LESS SMOKE YES-34 NO EFFECT-2 AV.=40%	FLUE WORK LESS-35 MORE-2 REDUCED 40%	IMPROVES STEAMING YES-45 NO-1	REDUCES FAILURES YES-42 NO-5	LESS FLUE STOPPAGE YES-37 NO-10	HONEY COMBING LESS-29 NEUTRAL-9	EFFECT OF ARCH PIPES BENEFIT-23 NEUTRAL-2	EFFECT ON FLUE LIFE ADDS-32 DECREM-4	FIRE BOX LIFE PROLONGS-5 SHORTENS-12 NEUTRAL-14	AVERAGE LIFE OF ARCH PIPE 14 MONTHS	AV. COST TO RENEW ARCH PIPE $4.25 EA.	WATER CONDITIONS ALL KINDS	ARCH PIPE CARE. WASH OUT AT EVERY BOILER WASH AND USE TUBE CLEANER	ARCH PIPE SETTING AV. ½" THRU SHEETS FERRULES-30, NONE-10 BELLED-23, BEADED-13	LIFE OF ARCH PASS.=3490 MI. FRT.=4425 MI. SW.=6,500 MI.			SUPPORT TUBES & STUDS	ARE ENGS DELAYED NO-29 YES-12	ARCH LABOR [illegible]	ENG. MEN ATTITUDE PRACTICALLY UNANIMOUS IN FAVOR OF ARCH	CROWN CLEAR 16 to 24 AV. 21"	FLUE SHEET SPACE-27 NO SPACE-16 AV. SPACE 5"	AV. OF % OF S.&C. 2.6%	LABOR DONE BY WASH? 16 SAY BRICKMEN 17 SAY B.M. & HELPERS	
	1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	18			19	21	23	24	25	26	27	28	
	PERCENT OF COAL SAVING	EFFECT ON OR % OF SMOKE ABATEMENT	EFFECT ON FLUE WORK AND % OF REDUCTION OF FREQUENCY OF CALKING	DO ARCHES MAKE MORE CONSISTENT STEAMERS WHEN UNDER DEMAND FOR MAX. POWER	DO ARCHES TEND TO REDUCE ENG. FAILURES FROM LEAKY FLUES OR LOW STEAM	DO ARCHES REDUCE FLUE STOPPAGE OR AMOUNT OF CINDERS CARRIED THROUGH	EFFECT IF ANY ON HONEY COMBING OF FLUE SHEET	EFFECT OF ARCH PIPES ON BOILER EFFICIENCY OR EVAPORATION	EFFECT ON LIFE OF SET OF FLUES	EFFECT ON LIFE OF FIRE BOX	AVERAGE LIFE OF ARCH PIPE	AVERAGE COST MATERIAL & LABOR FOR RENEWING ONE ARCH PIPE	WATER CONDITIONS	PRACTICE OR RECOMMENDATION ON CLEANING AND CARE OF ARCH PIPES	RECOMMENDATIONS ON ARCH PIPE SETTINGS ETC.	AVERAGE LIFE OF SET OF BRICK PASS.	FRT.	SW.	NUMBER OF SUPPORT OF ARCHES	ARE ENGS HELD LONGER AT TERMINAL ACCOUNT OF ARCHES	BRICK ARCH LABOR COST LOCO. PER MO.	ATTITUDE OF ENGINEERS AND FIREMEN	SPACE BETWEEN BACK OF ARCH & CROWN SHEET	SPACE IF ANY BETWEEN FLUE SHEET AND ARCH	% OF STOKER [illegible]	IS WORK DONE BY BRICK MEN OR BOILER MAKERS & HELPERS	REMARKS
1	SAVES COAL		LESS LEAKY FLUES	YES	YES	YES, IF ARCH PROPERLY SET							GOOD, FAIR AND BAD							YES		DESIRE THEM	20 to 24	CORNERS WITH 4" [illegible]			
2	ABOUT 5%	NONE		YES	NO	NO	NONE	SLIGHT INCREASE	NO DIFFERENCE	[illegible]	ABOUT 5 MO.	CAN'T SAY	FAIR	CLEANED ONCE EACH WEEK	1" OFFSET & BELL 30° NO FERRULES						CAN'T SAY		20"	5" SPACE	CAN'T SAY		NO EXP. FOR 12 YRS.
3		25 to 30%	20% LESS LEAKAGE	YES	YES	YES	REDUCES HONEY COMB		NONE	SHORTENS LIFE		$3.50	GOOD & BAD	WASHED AT BOILER WASH	¾ TURNED OVER, COPPER FERRULES	3 to 4 WEEKS		3 WKS.	TUBES	NO		FAVORABLE	20"	6" SPACE		B.M. HELPERS	
4	SAVES COAL	ABATES SMOKE	SAVES FLUE WORK	YES	YES	DO NOT		IMPROVES BOTH	INCREASES LIFE	DETRIMENTAL	ABOUT 18 MO.	$7.00	GOOD	WASHED OUT EVERY 30 DAYS	⅛" BELLED TO 45° FERRULES NOT USED	45 DAYS	30 DAYS	60 DAYS	TUBES STUDS	YES	$1.00	FAVORABLE	20"	3" SPACE		HELPERS	
5	SAVES COAL ON SMALL FIRE BOXES	ABATES SMOKE		YES, ON SMALL FIRE BOXES		CAN SEE NO DIFFERENCE													[illegible]					6 INCH OPENING			
6	14.7%	ABATES SMOKE	25% REDUCTION	YES	YES	YES	NO DIFFERENCE	ABOUT 3% FOR FIRST 3 TUBES	PROTECTS FLUES	PROLONGS LIFE OF SAME	AT LEAST ONE YEAR			WASH OUT TUBES AT EACH BOILER WASH OUT	⅜ TO TURN OVER OBJECT TO FERRULES							FAVORABLE	24"	5" SPACE		SPECIAL BRICK MEN	
7	15%	50% ABATEMENT	REDUCES FLUE TROUBLE	YES	YES	YES	NOT MUCH EFFECT	5 to 8%	INCREASES LIFE [illegible]		2 to 5 YRS.	LABOR [illegible]	GOOD & POOR	WASH OUT ARCH TUBES EVERY 30 DAYS	⅜ BELLED TO 45° NO FERRULES	3000 to 30,000 MI.			TUBES	NOT UNLESS [illegible]		ALL FAVORABLE	14" to 16"	[illegible]		SPECIAL BRICK MEN	
8	ABOUT 5%	SCARCELY NOTICEABLE	INCREASE FLUE WORK	NOT ON TEN WHEEL ENG.	INCREASE FAILURES	NO THE REVERSE	[illegible]	NO BENEFIT	10% DECREASE	CAUSE SIDE SHEETS TO LEAK			FAIR TO POOR	RECOMMEND CLEAN THOROUGHLY AT BOILER WASH	¾ FOR TURNING OVER NO FERRULES	GOOD [illegible]						ENGINEERS FAVORABLE	12"	NONE		[illegible]	[illegible]
9	25%		30% REDUCTION	YES	YES	YES	PREVENTS HONEYCOMB		INCREASE LIFE 30%		2 YEARS	LABOR COST $2.00	FAIR	THOROUGHLY WASHED EVERY 25 DAYS	¾ MARGIN, NO FERRULES	7000	5000		TUBES STUDS	NO	$1.00	DON'T GO OUT WITHOUT THEM	25"	6" SPACE	1%	SPECIAL MEN	
10	20%	30% ABATEMENT		YES	YES	YES	PREVENTS HONEYCOMB	NOT ANY	INCREASES LIFE	NO EFFECT	1 YEAR	$4.00	GOOD	WASH & SCRAPE WITH ROD	⅜ MARGIN, BELLED COPPER FERRULES	[illegible]	[illegible]		TUBES	NO		ALL WANT THEM	21"	NO SPACE		HELPERS	
11	5%	37½% ABATEMENT	MAY BE 50% [illegible]	YES	YES	YES, IF PROPER BOXES	NOT ANY		NO RECORD	HARD ON SIDE SHEETS	NO RECORD	$4.00	GOOD	PNEUMATIC CLEANING EVERY FOUR TRIPS	⅛ MARGIN & COPPER FERRULES	3,200			STUDS	NO		ALL WANT THEM	25"	NO SPACE	[illegible]	SPECIAL ARCH MEN	
12	ABOUT 15%	NONE	NO EFFECT	YES	YES	YES	NO EFFECT	DO NOT LIKE [illegible]	NO EFFECT	REDUCE LIFE OF FIRE BOX			FAIR						STUDS								
13	8 to 12%		30% OR MORE	YES	YES	YES	REDUCES HONEYCOMB	IMPROVES BOTH	INCREASES LIFE 4 TIMES	NO EFFECT	40,000 MI.	$4.00	GOOD, FAIR & BAD	CYCLONE CLEANER AT EVERY WASH OUT	¾ FLARED & HALF BEAD COPPER FERRULES	5000	2800	2400	TUBES	NO	72¢	95% FAVORABLE	[illegible]	NO SPACE	3%	COMMON LABOR	
14		ABATES SMOKE	REDUCES FLUE TROUBLE	YES	YES	YES	BEST REMEDY FOR PREVENTING	IMPROVES BOTH	INCREASES 33⅓%	INCREASES	3 to 4 YRS.	[illegible]	FAIR	CYCLONE CLEANER	⅛" FLARE, ⅛" BEAD COPPER FERRULES	[illegible]	[illegible]	[illegible]	TUBES	NO		ALL IN FAVOR	18"	NO SPACE		B.M. & HELPERS	
15	10%	30%	25%	YES	YES	YES	[illegible] PREVENTS	IMPROVES STEAMING	INCREASES 20 to 25%	[illegible]		$5.25	GOOD & BAD	TURBINE CLEANER AT BOILER WASH	⅛ FOR BEAD COPPER FERRULES	45 To 60 DA.	30 To 40 DA.	60 To 90 DA.	TUBES	YES	[illegible]	FAVORABLE	VARIES	NO SPACE		B.M. HELPERS	
16	15 to 20%	50%	REDUCED TO A MINIMUM	YES	YES	YES	ALMOST ELIMINATED		INCREASE 100%	NOT ANY			GOOD		¾ TURNED OVER COPPER FERRULES	4 MO.	3 MO.	6 MO.	TUBES	[illegible]	$1.50	ONCE USED ALWAYS WANT	24"	3½" to 4"		SPECIAL ARCH MEN	
17	2% TON PER 100 MI.			YES	YES	YES	[illegible] HONEYCOMB	GOOD WITH PROPER CARE				LABOR $1.00	FAIR & HARD	ROTARY CLEANER	⅛" TO BEAD	2 MO.	1 MO.		TUBES	YES		FAVORABLE	VARIES	NO SPACE		B.M. HELPERS	
18	8 to 12%		40% OR MORE	YES	YES	YES	REDUCES HONEYCOMB	IMPROVED BOTH	INCREASES LIFE 4 TIMES	NO EFFECT	40,000 MI.	$4.00	GOOD FAIR & BAD	CYCLONE CLEANER AT EVERY WASH OUT	⅛ FLARED & HALF BEAD COPPER FERRULES	5000	2,800	2,400	TUBES	NO	72¢	FAVORABLE	19" to 22"	NO SPACE	3%	COMMON LABOR	
19	10%		REDUCTION	YES	YES				LIFE LENGTHENED		[illegible]	$5.26	TREATED	SCRAPED & RATTLED AT BOILER WASH	⅜ BELLED 30° FERRULES	2 MO.	6 MO.		TUBES	[illegible]	$2.00	FAVORABLE	[illegible]	CORNERS ONLY		[illegible] HELPERS	
20		SLIGHT ABATEMENT	25% IN BAD WATER			NO [illegible]	NO DIFFERENCE												STUDS				18"	6" to 10"			
21	9%			YES	YES	YES			PROLONGS LIFE	CANNOT SAY	CANNOT SAY	LABOR $2.00	POOR	WASH OUT AT BOILER WASH	⅜ TO TURN OUT AT 45° COPPER FERRULES				TUBES				21"	4" to 7"		SPECIAL BOILER MEN	
22		ABATES SMOKE	PROTECTS FLUES	YES	YES	NO		GOOD EFFECT	NO RECORD	SHORTENS LIFE	4 MO. TO 4 YRS.	$4.00	GOOD & POOR	WASH OUT AT BOILER WASH	⅛" BELLED COPPER FERRULES	3,500			TUBES	NOT UNLESS LEAKING		FAVORABLE	[illegible]	2 to 4"		SPECIAL MEN	
23	13%	ABATES SMOKE	PROTECTS FLUES	YES	YES	YES	PREVENTS HONEYCOMB	4% GAIN	INCREASES 50%	PROLONGS LIFE	3 YRS. IF KEPT CLEAN	$4.60	GOOD & POOR	WASH OUT AND AIR HAMMER TUBES	⅛ 45° FLARE COPPER FERRULES	6,000	8,000	30 DA.	TUBES & STUDS	NO		FAVORABLE	18"	LITTLE AS POSSIBLE	3⅓%	SPECIAL MEN	
24	20%	ABATES SMOKE	SAVES FLUES	YES	YES	YES	MUCH REDUCTION	NONE IN USE	LENGTHENS LIFE	HARD ON [illegible]	DON'T USE THEM		FAIR			30 DA.	3 MO.		STUDS	NO		FAVORABLE CAN'T DO WITHOUT	24"	TIGHT AT SHEET		GRATE & FLUE CLEANER	
25	SAVES COAL		LESS LEAKY FLUES	YES	YES	NO DIFFERENCE	NO DIFFERENCE		INCREASE LIFE	HARD ON SIDE SHEETS	30 TO 60 DAYS	$4.00	FAIR	ARCH TUBE CLEANER AT BOILER WASH	⅛" FOR BEAD & USE COPPER FERRULES	15 DA.	15 DA.		TUBES	NO		FAVORABLE		3" to 4"		B.M. HELPERS	
26		66%	50% REDUCTION	YES	YES	NO EFFECT	NO DIFFERENCE			NO EFFECT	2 YEARS			CYCLONE CLEANER	⅛ TO TURN OVER COPPER FERRULES		45 DA.	60 DA.	TUBES	NOT UNLESS LEAKING		MAJORITY FAVORABLE	24"	4" SPACE		HELPERS	
27	10%	75%	25% [illegible]	– YES	YES	YES	50% LESS	BENEFIT			NOT USED		ALL KINDS	NOT USED	RECOMMEND ⅛ BELLED NO FERRULES	5,000	3,000		STUDS	NO	50¢	ALL WANT THEM	22"	NOT ANY		SPECIAL [illegible]	
28	10%		100%	YES	YES	YES	REDUCES HONEYCOMB		100% LONGER	10%			GOOD	RECOMMEND WASH OUT OFTEN AS NECESSARY					[illegible]	NO		SOME FAVORABLE SOME NOT	20"	NO SPACE		HELPERS	
29		40%			8 SOFT WATER	YES			NO EFFECT	NO EFFECT	6 MO.			SODA ASH TO KEEP TUBES CLEAN						YES		FAVORABLE	24"	5"		B.M. HELPERS	
30	SAVES FUEL	ABATES SMOKE	SAVES FLUE WORK	YES	YES	YES	SAME REDUCTION	IMPROVES STEAMING	INCREASES LIFE			LABOR $1.50	POOR & HARD	ROTARY CLEANER	¾ TO TURN OVER COPPER FERRULES	1 MO.	1 MO.		TUBES	NO		FAVORABLE	16" to 24"	NO SPACE		B.M. HELPERS	
31						YES		GOOD EFFECT	INCREASE LIFE			LABOR $1.50	BAD		⅛ MARGIN, COPPER FERRULE				STUDS				24"	6" SPACE			
32	6⅔%	ABATES SMOKE	NO EFFECT	YES	NO	YES	PREVENTS HONEYCOMB	IMPROVES	DECREASES LIFE	MAY OR MAY NOT		$5.00	GOOD	CYCLONE CLEANER	⅛ FOR FULL BEAD NO FERRULES	[illegible]	8,000		TUBES	YES	$2.00		26"	4" to 5"	2%	B.M. HELPERS	
33	LARGE SAVING	ABOUT 20%	CUTS DOWN FLUE WORK	YES	YES	YES	ALMOST PREVENTS IT		INCREASE LIFE	NO EFFECT	1 to 2 YRS.	$5.00	FAIR	CYCLONE CLEANER EVERY WEEK	⅛" MARGIN & BEADED COPPER FERRULES	30 DA.	30 DA.	60 DA.	TUBES	NO LESS DELAY		FAVORABLE OBJECT TO [illegible]	20 to 24	4" to 6"		SPECIAL ARCH MEN	
34	20 to 25%	50%	50%	YES	YES	YES	ALMOST PREVENTS	MORE OF BOTH	33⅓%	DECREASE 20%	1 YEAR	$2.00	FAIR & POOR	LIBERTY CLEANER	⅛" MARGIN, BEADED COPPER FERRULES	2,800	3,000		TUBES	NO LESS DELAY	$3.00	DON'T GO OUT WITHOUT ONE	22"	NO SPACE		SPECIAL MEN	
35		ABATES SMOKE	PROTECTS FLUES	YES	YES	YES	DECREASES HONEYCOMB	IMPROVES BOTH	INCREASES LIFE	NO EFFECT	3½ MO.	$2.00	ALL KINDS	CLEAN WITH LIBERTY TURBINE	⅛" MARGIN, BEADED COPPER FERRULES	2,000	1,500		TUBES	NO		90% FAVORABLE	18"	[illegible]		B.M. HELPERS	
36		5%	20%	YES	YES	YES	GOOD EFFECT		20%		10 MO.	$1.00	FAIR	WASH OUT AT BOILER WASH & USE 1" WIRE ROPE	⅛" FOR BEADING NO FERRULES	60 DA.	45 DA.	90 DA.	TUBES	NO	$1.50	SPLENDID	16"	8" SPACE		SPECIAL MEN	
37	10%	70%	REDUCES	YES	YES	YES	NONE	PROTECTS		SHORTENS LIFE			ALL CONDITIONS		⅛" FOR TURNING COPPER FERRULES	5000	2,800		STUDS	NO	50¢	ASK FOR THEM	22"	NONE		HELPERS	
38	10%		20%	YES	APPARENTLY THEY DO	NOT MUCH [illegible]	VERY LITTLE [illegible]						GOOD	ARRANGING TO CLEAN WITH TURBINE	⅛ BELLED OUT COPPER FERRULES				TUBES	YES		MAJORITY FAVORABLE	24"	[illegible]		BOILER WASHERS	
39	7%	10%	NO EFFECT	YES	NO EFFECT	NO	NO EFFECT	LITTLE IF ANY EFFECT	NO EFFECT	SHORTENS LIFE	24 DAYS	$3.00	POOR	CLEAN WITH TUBE RATTLER	⅛ FOR BEAD USE FERRULES	400	300		TUBES	YES		ALL FAVORABLE	42"	3" SPACE		SPECIAL BRICK MEN	
40	1 TON PER 100 MI.	66%	90% REDUCTION	YES	YES	YES	DECREASE HONEYCOMB	IMPROVES STEAMING	INCREASES LIFE		6 to 8 MO.	$4.00	FAIR & POOR	TURBINE CLEANER	⅛ MARGIN FOR TURNING COPPER FERRULES	10 DA.			TUBES	NO		FAVORABLE	[illegible]	2 to 4"		SPECIAL BRICK MEN	
41				YES	YES				[illegible]	NO EFFECT	[illegible]	$3.00	GOOD	USE CYCLONE CLEANER AT EVERY WASH OUT	⅛ MARGIN & BEADED USE COPPER FERRULES							FAVORABLE [illegible]	18" to 24"	NO SPACE		SPECIAL ARCH MEN	
42	ABOUT 10%	12%	REDUCES FLUE TROUBLE	YES	YES	IN SOME CASES	REDUCES HONEYCOMB	AIDS CIRCULATION	INCREASE [illegible]		6 to 12 MO.	$5.00	NOT POOR	TURBINE CLEANER	⅛ TURN OVER & BEAD NO COPPER FERRULES				TUBES	NO LESS DELAY		FAVOR ARCHES	18 to 20	NO SPACE		B.M. HELPERS	
43	10%		25% REDUCTION	YES	YES	YES	ALMOST PREVENTS		25% INCREASE	SIDE SHEETS CRACK SOONER			GOOD, FAIR & POOR		⅛ BEADED, COPPER FERRULES, FRONT END	30 DA.	25 DA.		STUDS	NO		STRONGLY FAVORABLE	24"	NO SPACE		B.M. HELPERS	
44	1 TON PER 100 MI.	LARGE REDUCTION	25% REDUCTION	YES	YES	YES, 50%	PREVENTS [illegible]	DO NOT USE PIPES	[illegible]	NO DIFFERENCE	30 DAYS		POOR	WASH OUT EVERY 30 DAYS	⅛ MARGIN, BELLED NO COPPER FERRULES	1,800			STUDS	NO		FAVOR ARCH	[illegible]	NO SPACE	3%	B.M. HELPERS	
45	[illegible]		INCREASE FLUE TROUBLE		NO									WASH OUT & USE ROD	⅛ NOT TURNED OVER COPPER FERRULES	10 to 30 DAYS			TUBES	YES							NO EXP. [illegible]
46	13%	50%		YES	YES	YES	PREVENTS HONEYCOMB				4 MO.		GOOD & POOR	WASH OUT & CLEAN WITH ROD	⅛ MARGIN FOR TURNING USE FERRULES	2 WKS.		3 WKS.	TUBES STUDS	YES		SOME FAVOR SOME DO NOT	18"	6"		B.M.	
47	SAVES COAL	ABATES SMOKE	REDUCES FLUE TROUBLE	YES	YES	YES			INCREASE [illegible]	HARD ON FIRE BOXES	ABOUT 1 MO.		FAIR	WASH ONCE PER WEEK	⅛ TO TURN OVER COPPER FERRULES	2 WKS.	11 DA.	3 WKS.	STUDS	YES		NEVER TO GO OUT WITHOUT ONE	18 to 20	3" SPACE		SPECIAL ARCH MEN	
48	15 to 20%	50%	50%	YES	YES	YES		IMPROVED BOTH	INCREASE LIFE 100%	NO BAD EFFECTS	12 MO.	$3.00	[illegible]	CLEAN WITH SCRAPER [illegible]	⅛ to ¼ MARGIN, BELLED		2500		TUBES	NO	$1.00	REFUSE TO GO OUT WITHOUT ONE	20"	1" to 2"		B.M. HELPERS	
49	10%	50%	15 to 25%	YES	YES	YES	REDUCES HONEYCOMB	MORE OF BOTH	INCREASE 25 to 35%	25% INCREASE	4 to 6 MO.	$3.00	GOOD, FAIR & POOR	USE LIBERTY CLEANER AT EACH BOILER WASH	⅛ TURN OVER & BEAD COPPER FERRULES AT FRONT	4,500	4,500	4,500	TUBES	NO	$1.00	VERY MUCH IN FAVOR	20"	OPEN AT CORNERS	3%	REGULAR ARCH MEN	[illegible]
50	12%	ABATES SMOKE	50%	YES	YES	YES	HONEYCOMB REDUCED	SLIGHTLY BENEFITS	5% INCREASE	NO EFFECT	[illegible]	$6.00	POOR	NOT USED	⅛ TURN OVER, BELLED COPPER FERRULES	90 DA.			STUDS	NO	$1.00	IN FAVOR	24"	NO SPACE		SPECIAL ARCH MEN	

POSSIBLE DETRIMENTAL EFFECT ON LIFE OF FIRE-BOX

The statistics show five claiming that the arch with arch pipes prolong the life of the box, twelve that the life of the fire-box is shortened, while fourteen report no effect, less than half reporting detrimental effects. This matter, then, calls for a little study. A careful review of the whole chart indicates that the experience of those reporting detrimental effect is largely in connection with brick arches supported on studs. It would, therefore, indicate that the effect of the arch on the life of the fire-box would depend upon the style of the arch used. It would indicate that arches of the proper design supported on tubes have no bad effect on the life of the fire-box. At any rate, we believe that we may safely draw the conclusion that the beneficial effect of the arch on the flues will at least offset any possible detrimental effect which the arch may have on the fire-box, so that item No. 10 cannot more than cancel the benefits of item No. 9.

ARE ENGINES HELD LONGER AT TERMINALS ACCOUNT OF ARCHES?

The vote on this item is 29 to 12, indicating that less than 30 percent of the members reporting find that there is a delay to the turning of power due to brick arches; several members reporting less delay to engines equipped with arches. This item will bear looking into. It would seem that the style of an arch has some bearing on this point. One man reports that there is no delay if sectional arch is used. The majority of those reporting no delays are using the sectional arches. Your committee, therefore, feels justified in saying that the delay in the turning of power claimed by some is not an unconquerable disadvantage. In fact, there are good grounds for argument that in the majority of cases this belongs on the other side of our ledger, due to the 40 percent reduction in roundhouse flue work.

COST, MATERIAL AND LABOR FOR MAINTAINING ARCH PIPES

The recapitulation shows an average of $4.36 total to renew one arch pipe. The average life of an arch pipe to be fourteen months. With four tubes in an engine there would be an average renewal of one tube every three and one-half months. At a cost of $4.36 each the arch pipe cost per year in box equipped with four tubes would be $15.26. This, we believe, represents a fair average for the cost of maintaining arch pipes.

COST OF MAINTENANCE OF BRICK, MATERIAL AND LABOR

It is a source of regret to your committee that the replies gave us no line on item No. 20 of our inquiry letter. This called for information on the cost of maintenance of brick per 1,000 engine miles. We have data, however, showing that the average life of a set of brick in passenger service is 5,490 miles, in freight service 4,425 miles and in switch 6,500 miles. Assuming 33,000 per year as a mileage, it would require about six arches per year for passenger engines, about 8 arches per year for freight engines. On account of the fact that there was but one reply to our question No. 20 we have omitted it from our table. Not having replies on the cost of arches we are obliged to make some assumption. We know from other sources that the cost per 1,000 miles for arches in wide fire-box locomotives will be between $1.00 and $3.00. These wide limits are necessary on account of the wide differences in conditions throughout the country. The condition of the water has a decided effect upon the life of an arch; the quality of the coal also has a decided effect, and the intensity or degree of severity of the service greatly affects the life of the arch. Assuming $2.00 per 1,000 engine miles as a probable average and a mileage of 33,000 miles per year, we have for the cost of brick $66.00 per year per locomotive. Add to this the brick arch labor in column 23 of the chart, given as an average of $1.70 per month, we have $20.40 for brick arch labor per locomotive per year; add to this the cost of maintenance of arch tubes, which we found above to be $15.26 per locomotive per year, and, figuring the storekeepers' cost at 2½ percent as the average shown in column 27, we have for adding to the above three figures an item of $1.65 per year per locomotive, making a grand total of $103.31 for the average cost for the yearly maintenance of brick arches and arch pipes in an average modern locomotive.

Compare this with the money value of the advantage of the brick arch, which we found to be on coal saving alone somewhere between $196 and $588 per locomotive per year, depending on whether price of coal is $1.00 or $3.00 per ton. Subtracting from these coal-saving figures the total cost to maintain the arches, we have, in districts where coal costs $1.00 per ton, the difference between $196 as coal saving and $103 as maintenance cost, a net of $93.00 per locomotive per year. Where coal costs $2.00 per ton we have a net of $275 per locomotive per year. Where coal costs $3 per ton we have a net of $485 per locomotive per year.

Thus you see that the price of coal greatly affects the net result.

To sum up the whole situation, weighing the advantages against the disadvantages, it appears from the replies received that brick arches are giving a very good account of themselves on twenty-six out of the thirty roads reported on.

Many railroads have recently adopted the use of brick arches and superheaters, not so much from a desire to burn less coal but in order to obtain more steam of a better quality, due to the necessity of having maximum sustained boiler power for a minimum of weight and operating expense.

The committee's recommendation, therefore, may be expressed as follows:

The improvements in brick arch construction and the advancement in the art of boiler maintenance, including care of arch pipes, render the disadvantages of the use of arches so small in comparison with the advantages derived as to warrant the general use of brick arches in soft-coal burning locomotives.

The Presence of Salt in Water

The use of the salinometer is, of course, a necessity well known to every sea-going engineer. But it is a matter of considerable importance and interest to know, when working with quite fresh water in the boilers, if any sea water gets introduced. The ordinary salinometer test is, not to say the least of it, a delicate one, and is only approximate for a small quantity of salt. Tasting is a rough and ready method, but I am afraid we are not all fitted with sensitive palates.

One gallon of sea water contains 6 ounces of solids, and this shows as 1/32 on the salinometer. That is, a single division on scale represents 3½ percent, so that the instrument cannot be considered quantitative in a chemical sense.

A test that will infallibly detect the presence of 15 grains of impurity per gallon, *i. e.*, one part in 4,700, or .02 percent, is by using nitrate of silver. To one ounce of suspected water add 2 drops of nitric acid; stir, add 1 drop nitrate of silver. If salt is present, there will be a white precipitate, which will darken on exposure to light.

A recent analysis of sea water gave: Chloride of sodium, 2.60 percent; chloride of potassium, .07 percent; chloride of magnesium, .28 percent; sulphate of lime, .11 percent; sulphate of magnesia, .26 percent.

The insoluble scale is produced by the sulphate of lime, which deposits at 287 degrees Fahrenheit to 310 degrees Fahrenheit, equal to 30 to 35 pounds pressure. Chloride of magnesium decomposes at ordinary boiler temperatures, giving rise to active hydrochloric acid in the water. Light should be excluded from the bottle containing nitrate of silver.

London. A. L. HAAS.

Boiler Inspection Law, State of Ohio

H. A. BAUMHART *

In an endeavor to protect the public from the recognized dangers attending the operation of steam boilers, a few States and several municipalities have for years past had laws requiring the periodical inspection of boilers. Many of these laws were, however, practically worthless owing to the fact that no rules or regulations were prescribed to guide the inspector in determining what was safe practice.

Inspectors frequently held office without the least reference to their ability as boiler experts, their appointment often being the reward for political services rendered to the party in power. Under such conditions it would sometimes happen that an inspector who was not competent, but who had the force of law back of him, would make rules that were a hardship to the steam user and in no wise contributed to safe boiler operation.

Massachusetts was one of the first States to enact a law requiring the annual inspection of steam boilers used in that State. It was of the generally inefficient character just described, as was proven by its use for several years. This law was amended in 1907 and made thoroughly efficient by a provision for a Board of Boiler Rules which was given authority to prepare rules and regulations governing the construction, installation, operation and inspection of practically all the steam boilers for use in the State of Massachusetts. In due time after this Board was appointed a set of rules was prepared, and these rules as amended from time to time have now been in use for a sufficient period to demonstrate their general value.

In 1910 the National Association of Stationary Engineers of Ohio took up the subject of a boiler inspection law for their State, and after careful consideration it was concluded that a law similar to that in force in Massachusetts would afford the greatest safeguard to human life and property and be most likely free from political influence. The association accordingly prepared a bill which, after several amendments, became a law by the signature of Governor Harmon on June 14, 1911. This law provides for the establishment in the office of the chief examiner of engineers at Columbus of a department to be known as the Board of Boiler Rules, to consist of the chief examiner of engineers as chairman, and four members to be appointed by the Governor. One of these is to be an employee of the boiler-using interest, one an employee of the boiler manufacturing interest, one an employee of the boiler insurance interest, and one an operating engineer.

The duties of this board are similar to the Board of Boiler Rules of Massachusetts; that is, to provide rules and regulations for the construction, installation, operation and inspection of steam boilers, and the devices with which they are equipped. The board was also to pass on any plans that might be deemed necessary to the safe operation of steam boilers, and to prescribe a standard form of certificate of inspection; also to examine all applicants for certificates as boiler inspectors.

It was provided in the law that on or after Jan. 1, 1912, all steam boilers, and their appurtenances (with certain specified exceptions) should be thoroughly inspected, internally and externally, and under operating conditions at intervals of not more than one year. It was also provided that such boilers should not be operated at pressures in excess of the safe working pressure stated in the certificate of inspection, and must be equipped with such appliances to insure safety of operation as may be prescribed by the Board of Boiler Rules.

The specific exception exempted from the operation of the law certain classes of boilers used in agricultural and other field work, locomotives and boilers under the jurisdiction of the Federal Government. Boilers for heating were exempt if operated at pressures below 15 pounds per square inch and provided with approved safety devices.

In preparing the bill it was desired to avoid placing any hardship upon the steam user or boiler manufacturer in the construction and installation of new boilers. This was accomplished by making the rules which govern the construction of new boilers effective July 1, 1912, or nearly a year after the rules were prepared. This gave ample time to arrange contracts for future delivery.

The bill was introduced to the General Assembly, and was known as House Bill No. 248. In its preparation the legislative committee of the National Association of Stationary Engineers had in mind two objects which to them were of vital importance:

First. They desired boiler construction and inspection which would safeguard human life and property.

Second. They insisted that the inspection system be uniform, and that the steam user should not be burdened with an expense or tax for similar services rendered by an insurance company.

To avoid such extra expense, and also to standardize the inspection work, the bill was made to provide for two classes of inspectors: one to be known as general inspectors, in the employ of the State, and the other to be known as special inspectors, in the employ of an insurance company authorized to insure boilers. These two classes of inspectors were to work under the same rules and regulations governing the inspection of steam boilers. Each inspector was to be examined and obtain a certificate of competency, and also a commission from the State authorizing him to inspect boilers.

The Ohio law differs slightly from that of Massachusetts in some respects. In Massachusetts an inspector, if employed by an authorized insurance company, after passing a satisfactory examination, is granted a certificate of competency which permits him to make inspections of boilers for use in the State of Massachusetts. This certificate is granted without requiring a fee. In Ohio a fee of $10.00 must accompany an application for examination for a certificate, and after a certificate has been granted the successful applicant is not authorized to inspect boilers for the State until a commission has been granted him by the chief inspector of steam boilers. In Massachusetts an inspector holding a certificate of competency can issue a certificate of inspection for a boiler which he finds to comply with all the requirements of the law, and no fee is charged the boiler owner for these certificates. In Ohio the certificate of inspection can only be issued by the chief boiler inspector, and the boiler owner is required to pay a fee of 50 cents for each certificate.

In compliance with the law the Board of Boiler Rules met on Aug. 9, 1911, for the purpose of formulating rules governing the construction, installation and operation of steam boilers. The subject was an important one, requiring careful consideration, as the State of Ohio ranks among the largest in manufacturing and mining industries, and probably has within its borders 25,000 steam boilers, 15,000 of which would on Jan. 1, 1912, be subject to the rules governing the inspection of them. The State of Ohio up to this time had never had a boiler inspection law. Its steam users and boiler manufacturers, therefore, were familiar only with such inspection require-

* Member of Board of Boiler Rules.

ments as the steam boiler insurance companies imposed, and in most cases the pressure allowed was that determined by the boiler manufacturer or an insurance company's inspector when insured. As power plants are designed to operate with a certain fixed minimum pressure, it was realized that any reduction to permit of a fully adequate factor of safety would, in many cases, cause a great hardship. The factor of safety under which some of the boilers were operated was problematical, but, judging from personal observation, a considerable number, perhaps 40 percent of the total in the State, had a factor of safety of 5; about 30 percent a factor of safety of 4½; 25 percent a factor of safety 4, and perhaps 5 percent a factor of safety of less than 4. The question most difficult for the Board to decide was what should be the minimum factor of safety for boilers already installed, and at what time in point of service should the pressure be reduced, in order to maintain safe operation and not create an unnecessary expense or hardship, or perhaps in some cases compel the mine or factory to close to avoid violation of the law?

The Massachusetts rule places the minimum factor of safety at 5, and this is increased when the boiler is ten years old. This high standard was obtained after several years of educational work in that State. It would seem to be an injustice to the steam users to extend that rule to Ohio at this time. The minimum factor of safety generally used in Ohio for the past ten years was 4. It was thought that this factor could be safely extended to cover all boilers already in use in Ohio until the steam users could become accustomed to a higher standard and arrange conditions to meet it. It was, therefore, recommended that the minimum factor of safety for boilers already installed be placed at 4, and that the inspector should increase this when the general condition of a boiler required it. This rule was unanimously adopted by the Board. It is recorded in Part 1 of the Book of Boiler Rules and is now a law.

When formulating the part of the rules governing boilers to be installed after July 1, 1912, the Board considered, in addition to safety, the question of standard boiler construction. Some States and several cities have boiler inspection laws which differ in but small details, but sufficiently so to prevent a boiler designed for one locality being installed in another, although meeting all the requirements of the law at the first location. Boiler manufacturers are placed at a serious disadvantage because of this situation, for it thus becomes necessary to know where the boiler is to be installed before it can be designed, a condition which tends to increase the cost of production. Manufacturers and contractors whose business requires the use of temporary steam power are inconvenienced by being prevented from removing boilers from one locality to another because of this difference in the inspection laws. The boiler manufacturers and steam users generally requested that the rules covering the construction of Ohio standard boilers be made similar to those adopted by the State of Massachusetts and the city of Detroit, believing that if Ohio followed those rules it would be an incentive for other States to follow them when inspection laws were enacted. After carefully analyzing the Massachusetts boiler rules the Board found that they covered in detail practically all the requirements of safety, and with the exception of a few slight changes relating to minor details adopted them, and they are found in Part 2 of the Book of Boiler Rules.

These rules apply to all boilers installed in Ohio after July 1, 1912. To avoid delay, additional expense, and perhaps rejection of a boiler, steam users, when ordering a boiler to be installed in Ohio, should specify that it comply with the Ohio standard rules. The law states explicitly that no certificate of inspection shall be granted on any boiler installed in Ohio after July 1, 1912, which does not conform to these rules. Boiler manufacturers, dealers and steam users should understand that new boilers in the State which are installed before July 1, 1912, cannot be installed as Ohio standard boilers unless they have been constructed to comply with the Ohio rules.—*The Locomotive.*

How to Apply a Fire-Box Patch

In answer to your request in the May issue for the best method of applying patches to the inside of fire-boxes I would submit the following:

Examine thoroughly the part about to be patched and make sure you embody all defective parts in your patch, as it sometimes happens after the patch is gotten out that in working it up you will discover further defects necessitating the enlarging of patch. Having determined the size of your patch, mark off on the side sheet the patch bolt line (which is usually located between the centers of stay-bolts), and from that leave ⅞-inch landing and cut the piece out. Mark the stay-bolt holes in the patch and bolt up the patch with the edges smoked or whitened for marking. Mark the cut-off edge and remove the patch; center-point the cut-off line on the patch. Shear 1⅞-inch landing from line. Then scarf down the edges of the plate to 3/16 inch thick. This treatment makes the plate more homogeneous and less liable to crack from the hole to the edge of the plate, also making it more ductile and reducing the amount of metal exposed to the fire.

Lay off your holes in the patch 1⅞ inches pitch for ⅞-inch patch bolts, locating a hole in each corner directly on the intersection of the top and side line of the patch bolts. Should it become necessary you can then extend your patch in any direction without having bolts out of line.

Punch or drill holes ⅝ inch. Bolt up the patch in the same position as when you marked the cut-out line. Drill through the ⅝-inch holes with a 25/32-inch drill; remove the patch and tap out your holes in the side sheet. Open up the holes in the patch to 29/32 inch, and countersink the holes with a suitable tool ground to 45 degrees. If the holes are tapped perfectly straight the patch-bolt facing tool can be dispensed with. Clean all burrs and scale from the plate where the patch is to be applied. Apply a copper gasket, No. 26 thick, on the lap of the patch less ⅛ inch from the outer edge. Bolt up the patch and put in all patch bolts, tightening same up with a wrench. Tighten the last one to the limit and lay up the plate with a punch or moon tool around the last two bolts, and try the bolt with a wrench for more slack. Nick the head and break it off. Treat each bolt in like manner. If the patch bolts are a good fit it is not necessary to calk this patch. Tap the stay-bolt holes from the outside. Put in bolts; cut off, leaving three threads for riveting. Rivet same and the patch is finished. W. HENRY.

Vancouver, B. C.

A Question for Readers to Answer

Is there a reliable rule for figuring the bracing for a rectangular tank? As, for example, for a tank 72 inches square, 96 inches high, made of 3/16 inch plate throughout. The top and bottom heads are flanged all around. The shell of the tank is made with the corners flanged or turned without the use of upright corner angles.

If angle stiffeners should be used for bracing the sides of the tank, should they be placed vertically or horizontally? What size should these angles be and how far apart should they be spaced?

If angle stiffeners are connected by flat-bar tie rods, what size should the rods be and how far should they be spaced center to center? The bracing must be so arranged as to prevent the sides of the tank from bulging or swelling when filled to its full capacity. TANK.

Design, Construction and Inspection of Locomotive Boilers*

The committee has the following report to make in regard to design and construction of locomotive boilers: The report on inspection was presented to the members at the last convention. A circular of inquiry was sent to all the members of the association in regard to their experience and recommendations concerning the construction of locomotive boilers. Replies were received from twenty-nine members, comprising a total of 29,355 locomotives, including the supplementary report that was presented at the convention. The intention of this committee is to give the different members the benefit of the experience of the different railways.

Type of Boiler—In no case is a special type of boiler used for any special service. One of the members advises that they use Belpaire boilers of crown-bar construction for road engines entirely on account of greater ease in maintaining stay-bolts. Another member advises that they use the Belpaire boiler as well as the radial stay boiler, and their experience with the Belpaire boiler is that it reduces the number of stay-bolt breakages. From the experience that they gained with Belpaire boilers they developed a system of cross-bracing, shown in Fig. 1, which has practically all the advantages of the Belpaire staying, and in addition it reduces the deadweight and is cheaper to construct.

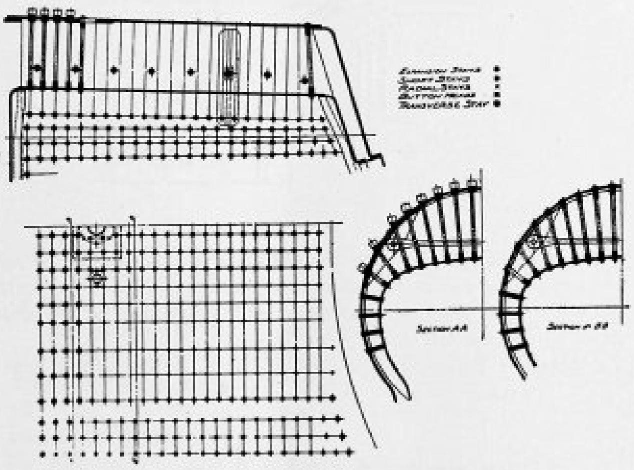


FIG. 1

A member of a road operating over 1,000 locomotives advises that they use Belpaire boilers with button heads to support crown sheet, claiming it is stronger, easier to clean and gives more steam space. Another member from a road operating 900 locomotives, advises that they have engines with Belpaire, radial stay and crown-bar boilers; crown-bar boilers are used on older type of engines and have proven unsatisfactory. Radial stay boilers have been used on later types of engines and have generally been satisfactory, except in bad-water districts where broken stay-bolts and cracked fire-box sheets have given more trouble as compared with the Belpaire boilers used in the same district. This is attributed to a more equal distribution of stress. Radial stay boilers are used on passenger, freight and switch engines, where Belpaire is used only on freight engines.

From the replies received from the different members, it is the consensus of opinion that the radial stay type of boiler is preferred, as it is easy to construct, giving more free circulation of water, less deposit of sediment on the crown sheet and easier to wash out; also the deadweight is kept down considerably.

Combustion Chambers—From the replies received the combustion chamber is only favored by five members. One member, who uses the combustion chamber covered by Fig. 2, advises that it shows a great economy in fuel, a decrease in the amount of smoke and cinders and increased mileage. No information was given in regard to maintenance. Another member advises that the reason they favor the combustion chamber in certain types of boilers, such as Mallet, is that it keeps the tubes a reasonable length and increases the heating surface of fire-box. No information was given as to the fuel economy derived from these combustion chambers, but a saving in maintenance and an improvement in performance is reported. The type of combustion chamber he uses is covered by Fig. 3.

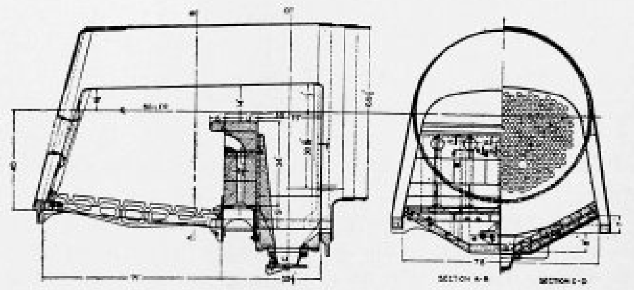


FIG. 2

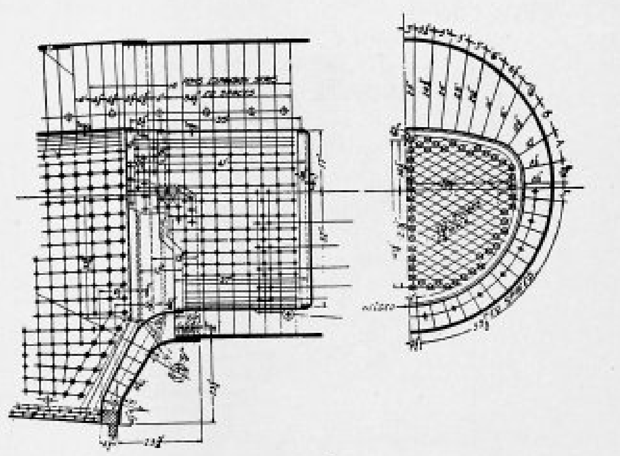


FIG. 3

Another member reports being in favor of combustion chambers, but does not have them on all engines. This member was from an anthracite road, and the particular claim was they thought they got better combustion and also derived a good deal of benefit in the way of protection of flues; particularly so, the boxes being extremely shallow below the flue sheet. Another member advises that they have had all combustion chambers removed on account of costing too much to maintain.

The advantages claimed by the use of combustion chamber are that it keeps the tubes within a reasonable length, protects the flue beads, increases the fire-box heating surface and gives better combustion.

The committee feels that a combustion chamber is desirable on boilers with extra long flues, such as Mallet and Mikados, but are not prepared to recommend any particular design.

* From report presented at the Master Mechanics' convention, Atlantic City, June, 1912, and published in the daily edition of the *Railway Age Gazette*, with whose permission the above abstract is reprinted.

Fire-Box—Continuous crown and side sheets are favored by all of the members except one. Therefore, the committee recommends the use of continuous crown and side sheet for new construction or with renewal of fire-box.

Mud-Ring Corners—The committee recommends mud-ring with large radius, and the flanges of the tube and door sheet should be carried back far enough to get at least three straight rivets through the ring. Scarf the inside sheets down to be properly fitted to the mud-ring by heating them. If the scarfing and the fitting of these sheets is given proper attention it will overcome leaky mud-ring corners that some of the members are now experiencing considerable difficulty with.

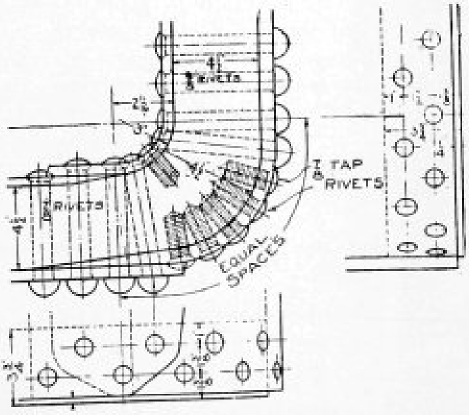


FIG. 4

Throat Sheet—From the replies received, the distance from the top of the grate to the bottom of the lowest boiler tube on wide fire-box engines is a minimum of 14 inches and a maximum of 26 inches, average about 22 inches. Narrow fire-boxes have a minimum of 13 inches and a maximum of 28½ inches, average about 20 inches. One member who uses hard coal advises a distance of 8⅛ inches minimum and 12 inches maximum. This height is limited, due to the design of the locomotive.

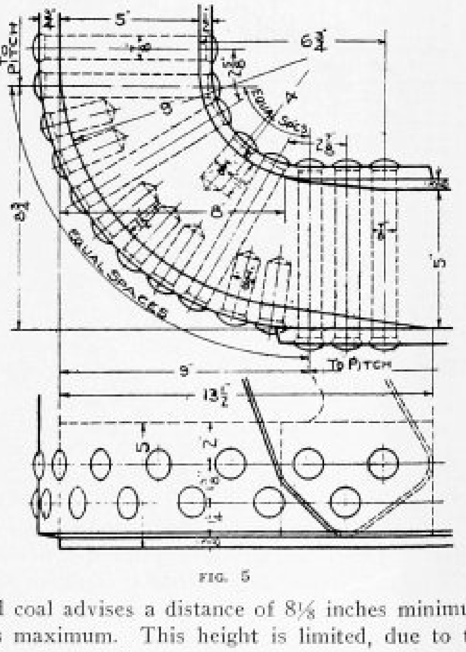


FIG. 5

The committee recommends as deep a throat sheet as the design of the locomotive will permit. The committee also suggests the design of throat sheet, as shown in Fig. 7, on boilers with sloping mud-ring, to allow for more uniform spacing of stay-bolts and location of arch tubes, and simplifies the flanging of the throat sheet and flue sheet. One of the members operating over 1,500 locomotives uses this design on the latest type of boilers. Boilers having a sloping mud-ring with a fire-box 60 inches long by 68 inches wide, throat sheet is 25 5/16 inches deep; fire-boxes 120 inches long by 61 inches wide, throat sheet is 15⅝ inches deep.

From the replies received in regard to thinning out of flue and door sheets, also the use of countersunk rivets where these sheets are joined to the side sheets, you will find the different methods followed out in Fig. 8. About 50 percent of the members thin out these sheets and apply countersunk rivets. It is generally acknowledged that the thinning of the sheets and the countersinking of rivets is necessary on oil-burning locomotives. The general practice seems to be to countersink these rivets about half way up the side sheet. No data were given in regard to which practice is the best from a maintenance standpoint.

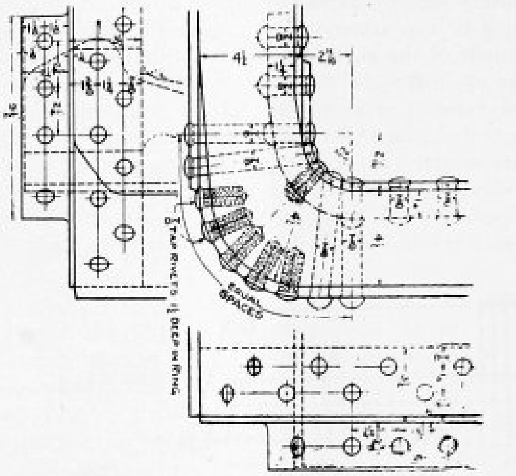


FIG. 6

Spacing of Rivets in Fire-Box Seams—The committee suggests ¾-inch rivets spaced 2 inches apart, as this is used by the majority of the members who replied to the circular.

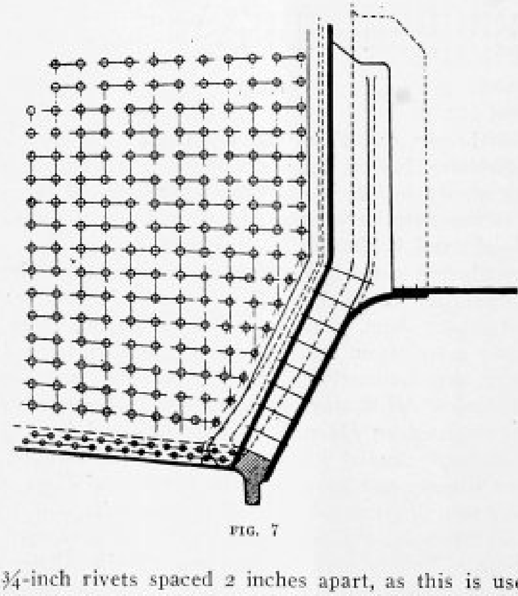


FIG. 7

Design of Fire-Door Hole—Fig. 9 shows various designs fire-door holes used by different members. Five members advise that they use style No. 2, which is the O'Connor type of fire-door. One of the members reports that they have 1,200 locomotives equipped with the O'Connor type of fire-door for a number of years. On boilers equipped with this type of fire-door flange they have had several cases where the door sheets have remained in perfect condition, although two sets of side sheets and a second back-flue sheet had been applied and cracked badly. In every instance the door hole remained in practically perfect condition when the rest of the fire-box was cracked to the point of renewal. Boilers equipped with this type of fire-door hole give larger water space, fewer stay-bolts about the door seam, seem to give freedom for expansion and contraction, and also largely prevent mud and scale collecting at this point. It seems to the committee that style No. 1 would have a tendency to collect mud and burn out. The committee has no choice between the other styles.

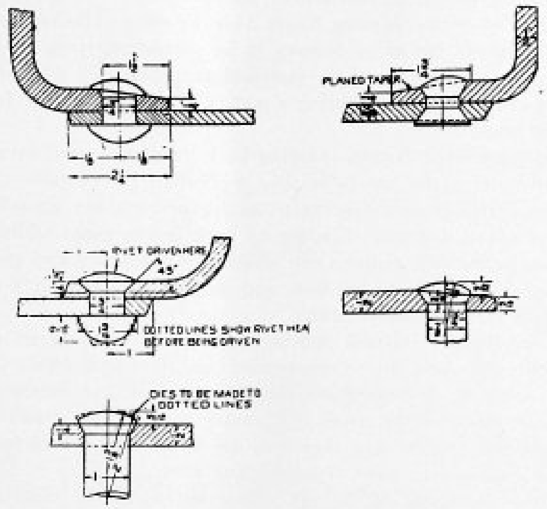


FIG. 8

Number and Size of Fire Doors—It is found that various sizes and numbers of door holes are used on different types of boilers.

Arch Tubes—Of the replies received, twenty members use 3-inch tubes, one member uses 2-inch tubes and one member uses 2¼-inch tubes. Eight members do not use arch tubes at all. One member supports brick arches with studs fastened into the side sheet.

Thickness of tubes used: .15 inch, .165 inch, .18 inch, .203 inch, .25 inch. Eight members use thickness of .18 inch. Eleven members use seamless steel, one member uses charcoal iron; thickness of tube not given.

Plugs or Plates for Covering Arch Tube Holes in Throat Sheet and Back Head—Fourteen members use brass plugs, one member uses extra large size brass plugs for covering the holes; these plugs are drilled for 2¼-inch plug, so as to avoid removing the large brass plugs when washing the tubes.

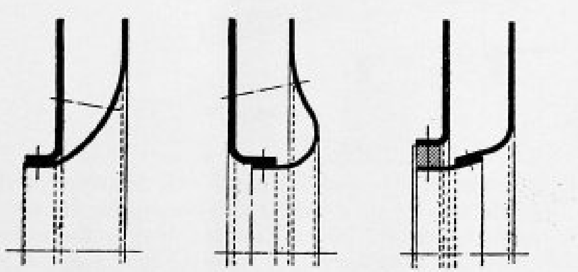


FIG. 9

Three members use plates with ball joints, as shown in Fig. 11, claiming greater ease in removing and applying in close quarters.

Method of Setting Arch Tubes—The setting of arch tubes varies. The replies received were indefinite as to just what practice they are following out. Six members did not state whether they use copper ferrules or not. Nine members advise that they use copper ferrules in setting arch tubes. Three members set the arch tubes without ferrules. Three members set the tubes with a roller expander and a sectional expander to be used in the ordinary manner to set out the tube, as shown in Fig. 12. Tubes are then beaded over with a bootleg tool, except by one member who bells out the tube on the water side to prevent the tube from pulling out of the sheet. This member does not use any ferrules. The other two members do use copper ferrules. Fig. 13 shows the arch tube setting as used by one member.

For the information of the members you will find complete

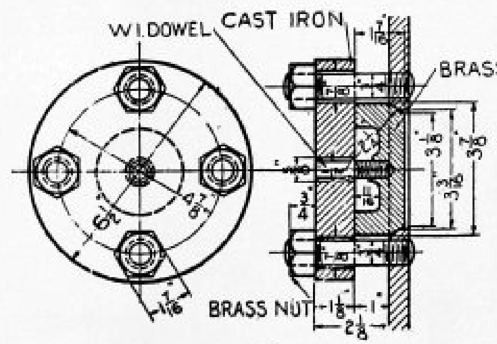


FIG. 10

set of instructions for setting arch tubes, which is being used by several large roads with success. This covers tubes expanded and beaded on the outside as follows:

Original holes in firebox sheet must be 3 3/32 inches in diameter. Worn holes must be reamed when more than 1/16 inch out of round. Sharp edges must be removed by slightly rounding with file or reamer. Copper ferrules must be used at both ends of arch tubes. Ferrules should be 3 inches outside diameter, .095 inch thick and ⅝ inch long,

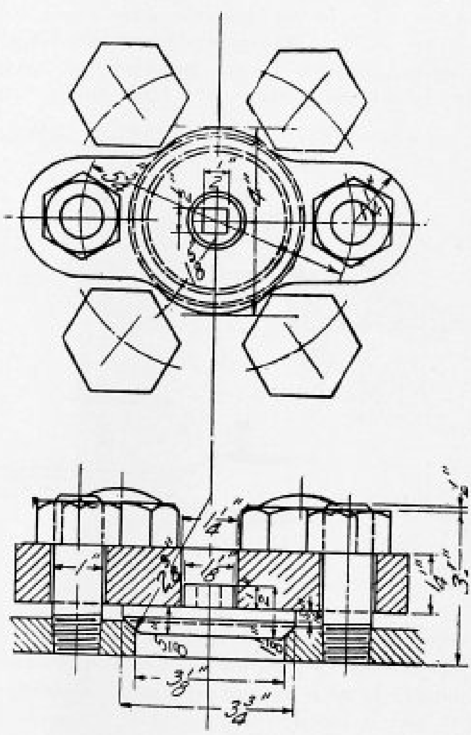


FIG. 11

expanded by carefully hammering on a round mandrel to snugly fit the hole. Ferrules should be set with 1/16 inch projection on each side of sheet and secured in place with a roller expander.

Tubes must be 3 inches outside diameter, .18 inch thick seamless drawn steel. The tubes should be cut to proper length and bent to template conforming with drawings. The length can only be determined by actual measurement of the firebox and allowance must be made for projection of ½ inch into water space at each end of firebox. Tubes must then be securely fastened with the roller expander. See Fig. No. 1, in Fig. 14.

After tubes have been set they must be flared at both ends with the flaring tools shown in Fig. No. 2 of Fig. 14. After the tube ends have been thoroughly flared the tube ends are then ready for beading.

Additional flaring, with tool shown in Fig. No. 3 of Fig. 14, is necessary to start the bead. The bead must then be formed with special beading tool, Fig. No. 4 of Fig. No. 14. Notice that it is not desired to form a full bead. The bottom of bead should stand 1/16 inch clear of the sheet.

These tubes should be thoroughly examined and cleaned at each washout of the boiler. At the least indication of scale formation in the tubes the pneumatic tube cleaner must be used. The tube cleaner should be secured to a length of ½-inch air hose, to which is attached another ½-inch hose for supplying water while cleaning. Care must be taken so as not to break the cleaning cutters by allowing the cleaner to be pushed through the opposite end of the tube. A stop must be provided on the hose set at the proper length for this purpose. The tube cleaner must be lubricated with signal oil fed through a lubricator in the air-supply pipe at the rate of 30 drops per minute. After cleaning, the tubes must be inspected by holding a light at the opposite end of the tube to make sure that the tubes are thoroughly cleaned and free from scale. Leaky tubes must be stopped from leaking by rolling with an expander. Before rolling the tube ends must be thoroughly cleaned from scale.

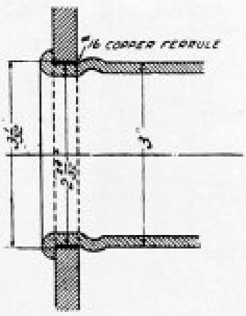


FIG. 12

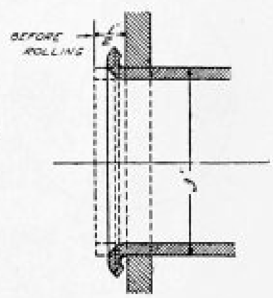


FIG. 13

The committee has been unable to get any information in regard to which type of flue setting gives the best service, therefore are unable to make a recommendation as to which type should be recommended as standard practice.

Radius of Flange in Back Tube Sheet—Replies received in regard to the radius in the back tube sheet where it connects to the crown sheets. Recommendations were made from ½ inch up to 2 inches. Some members had trouble with cracked sheets and leaky seams with large radius; others had trouble with the small radius. One member advises that he is now experimenting with a 4-inch radius, and it seems to give good satisfaction, but it has not been in use a sufficient length of time to give a complete report. Two members increased the radius from ⅞ inch to 2 inches, and had considerable trouble with the flue sheet working up and the flanges cracking. Two-inch radius has been discarded, and they are now using ⅞ inch, which improves the condition but does not eliminate the difficulty entirely. Another member reports a 3-inch radius satisfactory.

Distance from Inside of Flange of Back Flue Sheet to Edge of Flue Holes—The committee recommends that a distance from the inside of the back flue sheet to the edge of the nearest flue hole to be ample to prevent the flue sheet cracking through the flange. This distance will vary, depending on the radius of the flange of the tube sheet. In tube sheets with ⅞-inch radius this distance should be at least 2 inches at the top, ⅞ inch on the side. Sheets with 2-inch radius, this distance should be at least 2½ inches at the top.

Throat Sheet Brace—The committee had the members submit designs of throat sheet belly brace used, and Fig. 15 shows twelve styles of braces, the design of brace for this location to be such as to avoid any mud pockets and so as to allow for proper circulation of water.

Method of Supporting Grate Side Frames—The committee recommends the grate frames to be supported from studs in the mud-ring or brackets fastened to the under side of the mud-ring, the latter forming a pocket for the grate side frame to fit into.

Sloping Back Heads—Sloping back heads are used by practically all of the members who replied to the circular. The slope varies from 8 degrees to 20 degrees, making an average slope of 12 degrees. Sloping of back heads gives additional room in the cab, reduces the weight of the boiler and gives a maximum length of fire-box, and still remains within a reasonable limit for hand firing.

Stay-Bolts—Uniform spacing of all stay-bolts in all parts of the fire-box is recommended by the committee. The majority of the members reported the use of button-head crown stays for the six to nine center rows of the crown sheet the entire length; two members use hammered heads for the first four or five rows from the flue sheet.

The committee favors the use of button heads on as many rows as the design of fire-box will permit, but recommend for the consideration of members the practice of using hammered heads on the first four or five rows back from flue sheet.

Sling Stays—Figs. 17 and 18 show the various types of sling stays in use by the different members and no difficulty with any of these types has been reported. Three members use a special flexible stay-bolt on all new equipment, and the use of this type of sling stays is also favored by, but not used by, another member. Sling stays are used to the extent of two, three and four rows back from the tube sheet on boiler with cumbustion chamber.

Flexible Stay-Bolts—Of the members who have replied all except one member use flexible stay-bolts. Most of the members apply these in the breakage zone. Five members are making full installation of flexible stay-bolts on boilers with wide fire-boxes, and one member uses them in the throat sheet only. One member has the following report to make:

"In February, 1907, engine received a new fire-box with a full installation of flexible stay-bolts, with the exception of

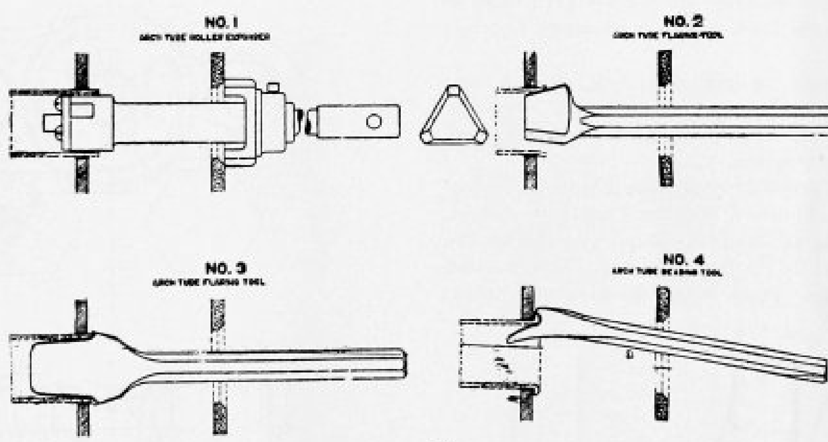


FIG. 14

four bolts under the auxiliary dome and four under the steam turret; also eight bolts which go on top at the back head. February, 1908, the engine received general repairs and the fire-box was in good condition. All caps were removed from the flexible stay-bolts and they were found to be O. K. In it was patched. Three of the mud-ring corners also had to have small patches applied. After rattling the scale from the fire-box sheets with a large hammer, it was found that forty of the flexible sleeves had cracked outside of the sheet, and on being taken out they were found to be crystalized, but no

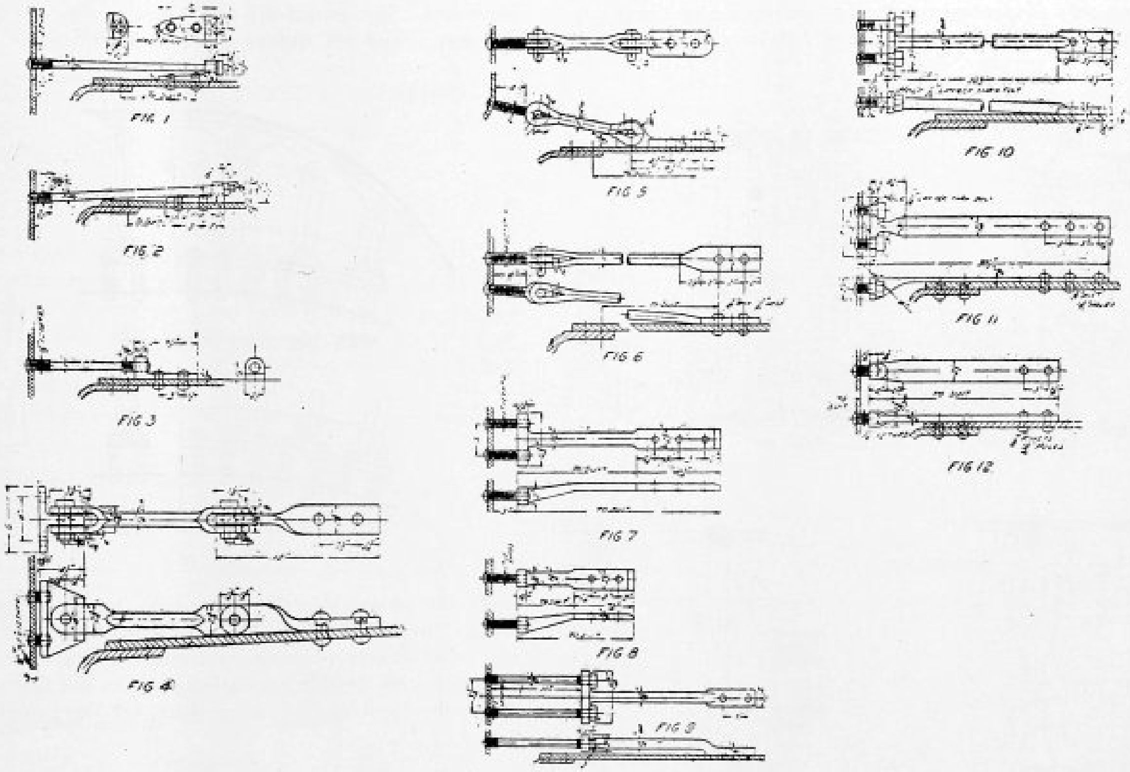


FIG. 15

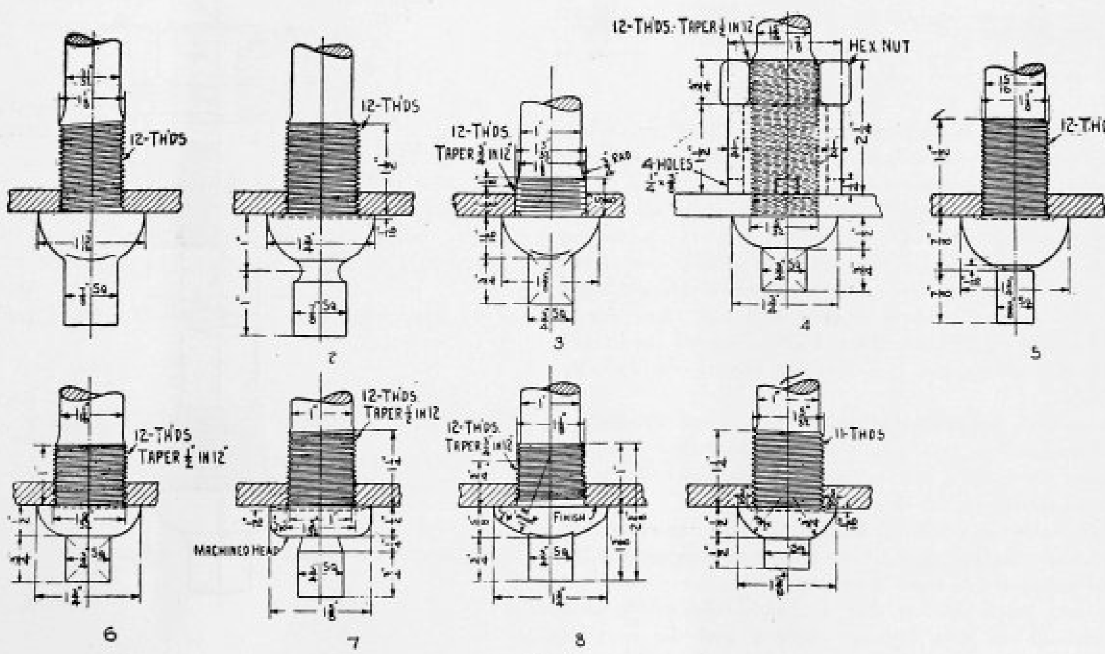


FIG. 16

April, 1909, it was found necessary to patch the top of the back tube sheet on account of the sheet cracking from the hole around the flange; this was done in the engine house. In October, 1909, the engine was given general repairs, and by this time the top of the back tube sheet had given out in two more places, but as the sheet was in good condition otherwise broken bolts were found. In 1911 the engine was again in the shop for general repairs, and had all the caps removed from the flexible stay-bolts and the bolts found to be O. K. A patch was applied on the top flange of the flue sheet, but the half side sheet seam in the fire-box was in good condition. When the engine is shopped again it will be necessary to renew the back flue sheet on account of its being patched. This engine has made 319,567 miles to November, 1911, and has lost no time due to broken stay-bolts."

One member advises that they have equipped some fire-boxes with a full installation of flexible stay-bolts, but can see no advantage in doing this. In their opinion the flexible stay-bolts are only advantageous when applied in the breakage zone, and they have discontinued making full installations and are only applying them in the breakage zone. However, a full installation of flexible stay-bolts in the throat sheet is being used by quite a few members with good results.

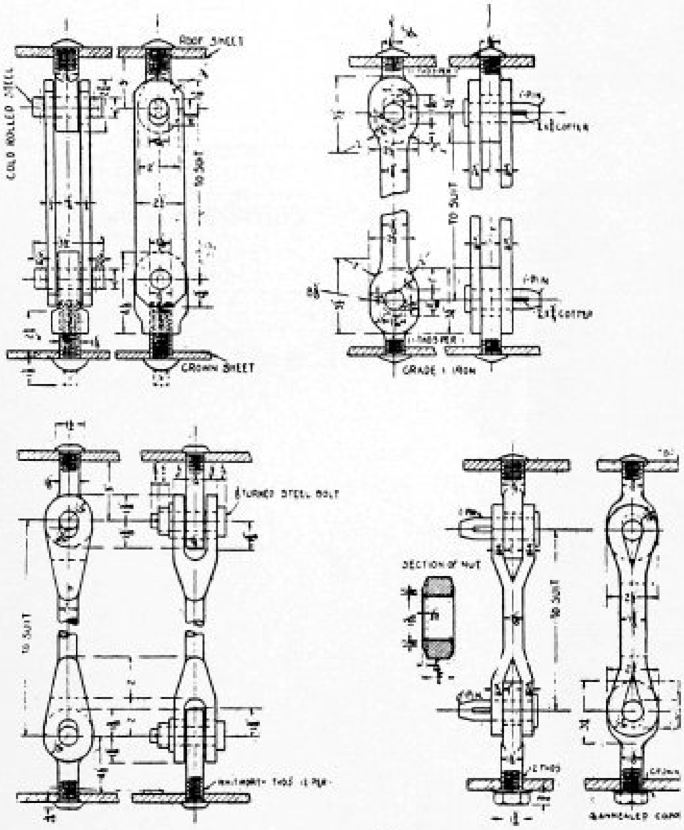


FIG. 17

Three members advise that they allow a certain amount of slack when applying flexible stay-bolts. Fig. 13 shows the amount of slack and the location followed out by one of the members. It is the brief that an application of this kind will decrease the number of broken stay-bolts and allow for a greater expansion and contraction, which prevents the cracking of fire-box sheets and increases the life of fire-box correspondingly.

The committee believes that this is a subject worthy of further consideration, and would suggest that some more of the members carry on a further investigation and make a report at some future date to this association.

Tube—It is the consensus of opinion of those reporting that 2-inch tubes are preferred, until the length of tube exceeds 16 feet, when 2¼-inch tubes are then preferred.

Taking into consideration that a 2-inch tube will give a greater amount of tube heating surface, and the cost of maintenance is less, the less damage is done to the tube sheets in working over the flues, the committee suggests that further consideration be given to the use of 2-inch tubes in lengths greater than 16 feet.

Thickness of Front Tube Sheet—One-half inch and ⅝ inch are used by the majority of the members who replied to the circular. One member uses 9/16 inch and another ¾ inch.

Thickness of Back Tube Sheet—One-half inch tube sheets are being used by sixteen of the members. Two members use 9/16 inch and one member uses ⅝ inch. All but three report having more or less trouble with flue sheets working up on account of frequently working on the flues, causing the flue sheets to crack across the top of the flange of the sheet. One member reports that this trouble occurs only on the radial type fire-boxes. The crown-bar and Belpaire type never crack in this way. The top flanges get bent down on the two latter types, the same as in the radial type, but no cracking takes place. They have used eye-bolts in crown sheet and roof sheet and sling braces between; also have a number of boilers equipped with flexible expansion stays in the first four rows across the front end of crown sheet, but there does not seem to be any method of bracing yet devised that will overcome this trouble. He suggested that the top of the flue sheet on radial type fire-boxes be made straight across top for 24 inches each side of center and make front end of crown sheet conform to this shape.

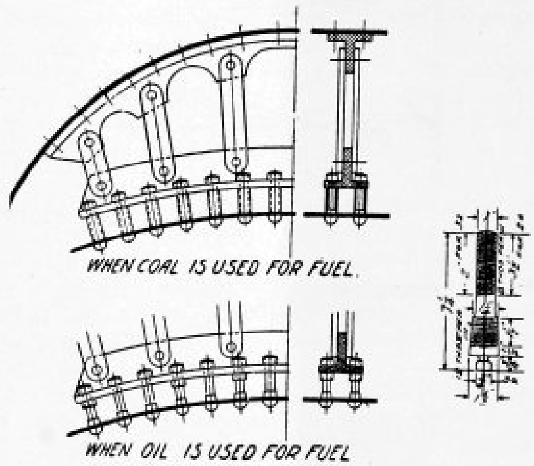


FIG. 18

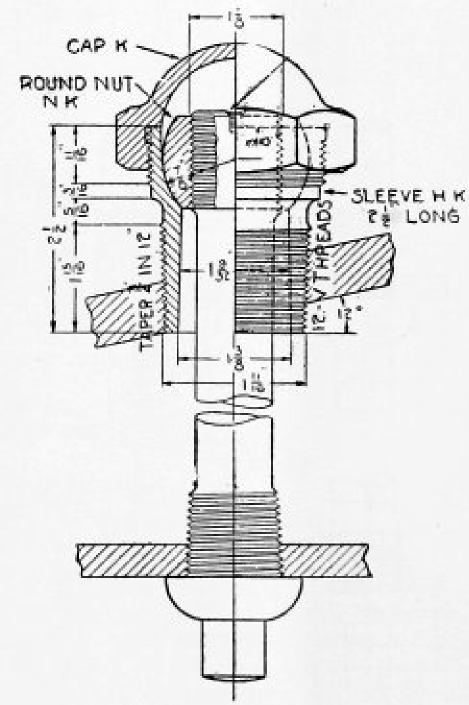


FIG. 19

Width of Bridges—The width of bridge in the front tube sheet varies from ½ inch to 15/16 inch. Three-fourths inch is used by the majority of the members. Width of bridge in the back tube sheet varies from 11/16 inch to 15/16 inch. Three-fourths inch is used by the majority of the members.

Flue Setting—Two members advise that they have tried out soft iron ferrules with very little success. One member advises that they had a limited experience trying to set flues in

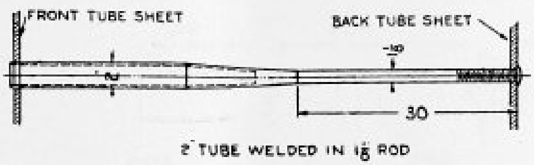


FIG. 20

the back flue sheet without any coppers, but found that it did not work satisfactorily, and that they are now experimenting with a combined copper and iron ferrule, but have not had these under a test long enough to make any report. One member advises that they use soft iron shims on the front flues to avoid excessive expanding.

Setting of Flues in the Front Tube Sheet—The consensus

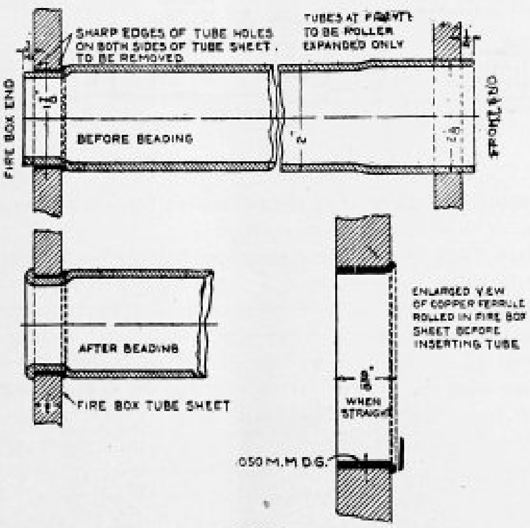


FIG. 21

of opinion of the roads reporting is that tubes should be rolled in the front tube sheet without any ferrules, and 10 percent of the flues, equally distributed, should be beaded with a beading tool.

Tube Setting in Back Sheet—Fig. 21 shows the practice followed out by some of the members in setting the tubes, which are giving good results. Fig. 24 shows the application, maintenance and removal of flues in locomotive boilers as used by three members. Tube setting of this kind gives a large bridge, good circulation of water at the back tube sheet, and at the same time the inside of the flue is reduced at the end, so that any cinders which will pass through the swedged end will not clog the flues. The instructions in connection with Fig. 24 are as follows:

Holes in the new firebox flue sheet shall be 1⅞ inches diameter. Holes in the new smokebox flue sheet shall be 2 1/32 inches diameter. Holes in an old flue sheet more than 1/32 inch out of round must be reamed (reamer Fig. 1). Inside and outside edges of the flue holes in

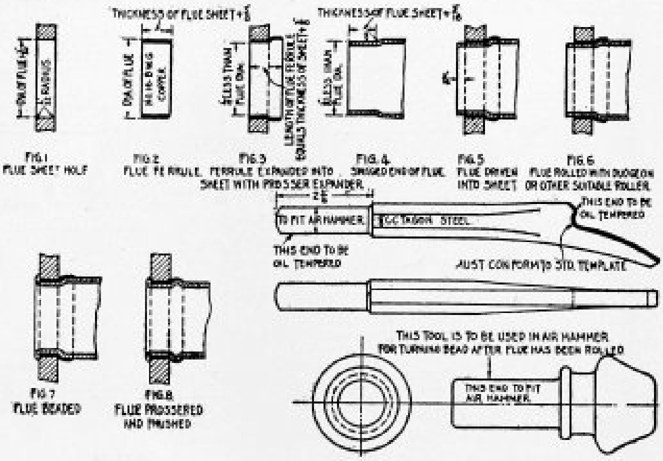


FIG. 23

both sheets must be slightly rounded to remove any sharp edges. The following is the method used:

Flue-sheet Holes (Fig. 1)—Care should be taken that holes in flue sheet are true, smooth and free from burrs and sharp edges. It is desirable that the flue hole have a fillet especially on the water side of about 1/32 inch radius. A sharp edge around the hole often cuts the ferrule in two, even cutting into the flue. The diameter of the flue hole should be the same as outside diameter of flue plus 1/32 inch.

Copper Ferrule (Fig. 2)—For New York this should not be far different from No. 16 B. W. G. In old flue sheets when the flue holes are large it is desirable to use enough heavier ferrules to bring the internal diameter of ferrule when expanded into flue sheet to ⅛ inch less than flue diameter. The ferrule should be set into flue hole flush with fireside and expanded into place with Prosser expander, Fig. 3.

Swaging Flue (Fig. 4)—Great care should be taken to give the swage the right length and to have it terminate in as abrupt a shoulder as possible. The flue, after it is swaged, should be annealed and the scale removed from the portion entering the sheet. Grinding this scale off by machine is desirable, but in the absence of a grinder the removal of the scale with a file will answer. The flue when driven into the sheet (Fig. 5) should extend 3/16 inch through the sheet on the fire side.

Rolling (Fig. 6)—The front end of the flues having been shimmed, when necessary, both the back and front ends are rolled with the dudgeon or other suitable roller, with proper appliances they may be safely and economically rolled by air; the rolling of the back ends must be done by an experienced boiler maker, and the motor must not be larger than a Thor No. 22, or its equivalent.

Beading (Fig. 7)—This may now be done with a beading tool in an air hammer. Do as little hammering with the beading tool as possible, and do not work bead to a feather edge, but leave as much metal as possible for future calking.

Expanding (Fig. 8)—Particular stress should be placed upon this, the most important step in the flue-setting process. Care should be taken that the flue shoulder, when heavily expanded, bears snugly and firmly against the flue sheet. Hammer not to exceed 4 pounds after prossering the front ends, then bead a sufficient number for safety which finishes the flue setting. Back ends of flues or safe ends when used in back flue sheet must be cut off square in pipe machine and burr removed by reamer. Wheel-flue cutters must not be used on account of leaving a heavy burr which splits when beading over

NOTE.—Air motor and roller are only to be used on initial setting.

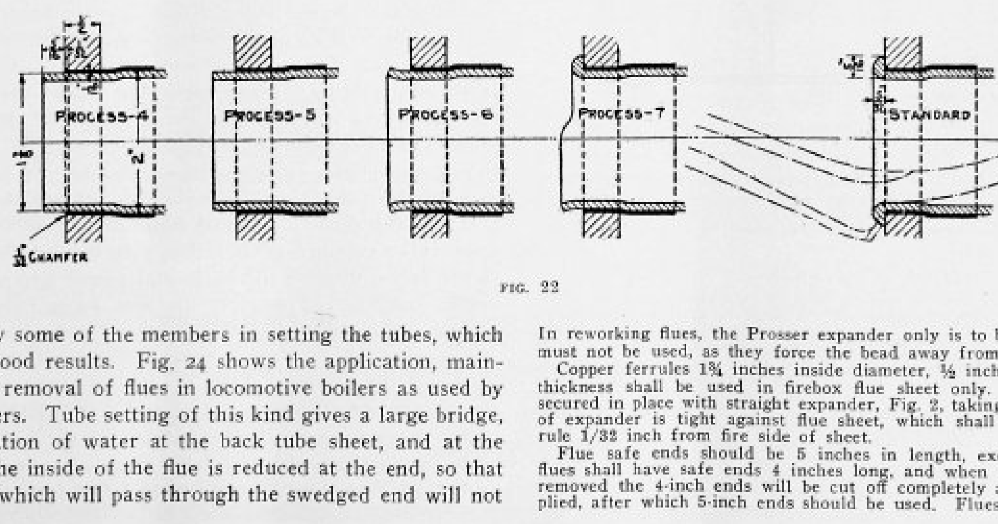


FIG. 22

In reworking flues, the Prosser expander only is to be used, and rollers must not be used, as they force the bead away from the sheet.

Copper ferrules 1¾ inches inside diameter, ½ inch long, .095 inch in thickness shall be used in firebox flue sheet only. Ferrules shall be secured in place with straight expander, Fig. 2, taking care that shoulder of expander is tight against flue sheet, which shall bring edge of ferrule 1/32 inch from fire side of sheet.

Flue safe ends should be 5 inches in length, except that new iron flues shall have safe ends 4 inches long, and when these flues are first removed the 4-inch ends will be cut off completely and 6-inch ends applied, after which 5-inch ends should be used. Flues shall be swaged as per Fig. 4, to 1 11/16 inches outside diameter by 3 inches long, including taper at firebox end, for new work; for old work, just enough to enter the copper ferrule. All scale must be removed from swaged ends of flues before application. Smokebox end of flues shall not be more than 1/32 inch less in diameter than holes in the smokebox flue sheet. If necessary, liners may be used.

Flues shall be placed in back flue sheet with a bar, Fig. 5, and project ¼ inch through the sheet. Gage, Fig. 6, shall be used in checking location of flues. Flues shall then be fastened at firebox end with straight sectional expander, Fig. 7. While flue is being fastened it may be held in place at front end, using bar, Fig. 5. Straight sectional expander shall be checked with master gage, Fig. 8. Before using sectional expander, and in order to obtain exactly the proper length of flue for beading, flues may be rolled lightly to fasten them in sheet with roller expander, Fig. 15. After all flues are fastened they shall be flared at firebox end, using flaring tool, Fig. 9, and long-stroke riveting hammer.

Flues at firebox end shall be expanded with sectional expander, Fig. 10, and long-stroke riveting hammer. Roller expander must not be used. Pin shall be driven into expander until flue is solid against flue sheet. This must be done three times, expander to be slightly turned before each operation. The expanding shall be performed as follows: First, two vertical rows, from center to top of sheet. Second, same rows from center to bottom. Third, the two horizontal center rows from center to right. Fourth, same rows from center to left. Fifth, all remaining flues. All flues must be carefully inspected after expanding to assure that recess in each flue is the full depth to recess in expander and even all around the flue. Sectional expander, Fig. 10, to be checked with master gage, Fig. 11.

Flues in firebox flue sheet shall be beaded with standard beading tool, Fig. 12, and short-stroke riveting hammer. Care must be taken so that nothing enters between head and flue sheet. Beading tool must conform accurately to master gage, Fig. 13, at all times. Smokebox end of flues shall be tightened with flaring tool, Fig. 14, before rolling takes place. All flues in smokebox end shall be rolled with roller expander, Fig. 15.

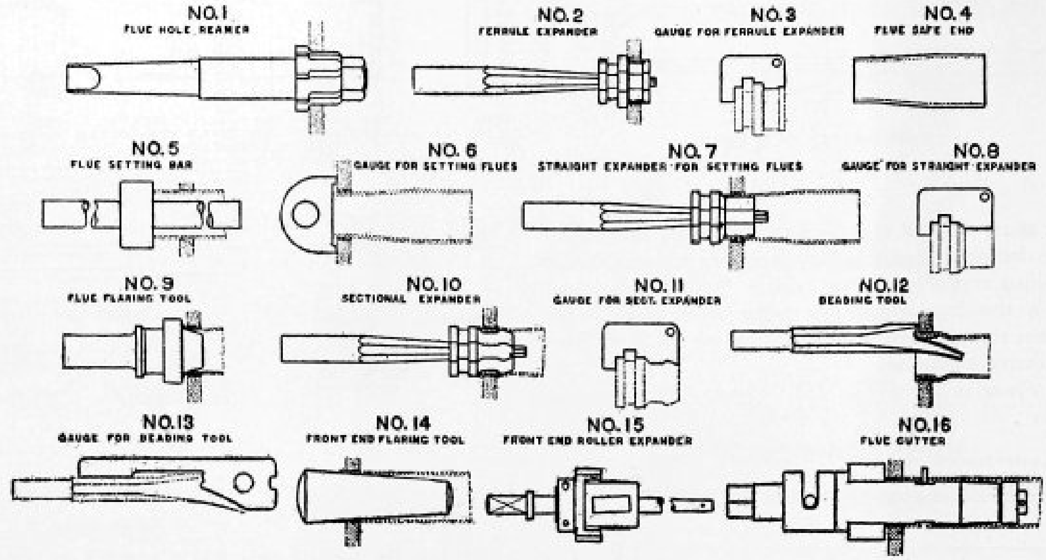


FIG. 24

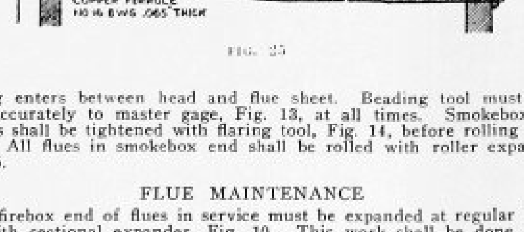


FIG. 25

FLUE MAINTENANCE

The firebox end of flues in service must be expanded at regular intervals with sectional expander, Fig. 10. This work shall be done when boiler is empty and all flues thoroughly cleaned out. Flue leaks in the firebox must be stopped with the sectional expander and not with roller expander nor beading tool. If beads are slightly away from flue sheet, standard beading tool shall be used to bring beads tight to sheet. Sectional expanders and beading tools must be kept standard by frequently comparing with standard gages. Any beading tool not conforming to gage must be sent to principal shop for repairs; these tools must not be repaired at any other shop. All shops and engine houses must be equipped with standard gages. All gages will be made where master gages are kept. To remove flues, use flue cutter, Fig. 16, for the front end, cutting off flues as close to the front sheet as possible. Back ends should be split as little as possible, so that it will not be necessary to use safe ends longer than 5 inches.

Setting of Superheater Tubes—Front Tube Sheet: Only eight members have had any experience with setting large superheater tubes. The practice followed out mostly is that the tube is rolled and beaded as shown in Fig. 25, and this type of setting is suggested by the committee for further consideration.

Back Tube Sheet—Eight members advise that they use copper ferrules; one member who omitted copper ferrules is having good success with this method. The consensus of opinion of the roads reporting is that the type of setting shown in Fig. 25 is preferred, and the committee suggests this setting, except that the copper ferrules should be No. 13, .095 inch thick, instead of No. 16, .065 inch thick.

Circulation of Water—The committee took up the question with the members whether any of them employed any special feature of design to facilitate circulation of water. It was found that no member has any special design for this purpose. Four members advise that they use baffle plates in the boiler shells, located ahead and rear of the dome. This is to prevent, as much as possible, the water from surging when making quick stops.

Seventeen members deliver the feed water to the boiler in the first course on the horizontal center line. The distance from the front flue sheet varies; the minimum distance is 22 inches and the maximum 6 feet. Five members advise that they deliver feed water to the boiler through the top as well as from the side. One of these members advises that they have never been able to find any particular improvement which the top check has over the side check. Two of these members prefer the water to be fed into the boiler from the top. Boilers having the checks on top of the boiler have a pan-shape deflector under the check valve which catches the water and prevents any direct stream of water falling on the top of the flues. One member advises that they deliver the feed water in the first course on the horizontal center line and use a deflector plate placed a short distance away from the boiler course. This is to direct the water to the bottom without striking the tubes. Four members have an attachment on the inside of the injector check to deliver water upward away from the tubes. One member advises that in addition to circulating water from the horizontal line of the boiler they have some locomotives with the delivery pipe passing through the back head, extending from 3 feet to 6 feet from the front tube

sheet, and the end of the pipe set to deliver water towards the side of the shell; the end of the pipe is submerged.

The committee has no recommendation to make in regard to any particular location where the water is to be delivered to the boiler, as any of the above arrangements seem to give entire satisfaction.

Auxiliary Dome or Manhole Cover to Facilitate Interior Inspection of Boiler—One member advises that they provide an auxiliary dome, or manhole, for interior inspection of boiler. The size of manhole is 15 inches in diameter, located a short distance ahead of the back flue sheet. This is submitted for consideration, as it makes inspection of the interior of the boiler possible without removing the throttle standpipe and dry pipe. One member of the association is using larger dome in new construction to accomplish the same result.

Surface Blow-off Cocks—Four members use surface blow-off cocks. One of these members has discontinued using them while the other two members, using surface blow-off cocks, have located them on a line with the second gage cock, and advise that they get good results from the use of both the blow-off cocks and surface blow-off cocks by getting rid of the mud and scale by blowing the boilers regularly. One of the members locates the surface cock on the left side of the boiler head just above crown sheet, and is connected to a perforated pipe about 4 inches above crown sheet and extends to the front end of crown sheet and branches both ways to within 8 inches of sides of boiler and about 6 inches above flues. Perforated pipes lead from cross pipe nearly to front tube sheet. When properly used this device is of considerable value in cases of foaming. One of the members, who operates about 1,400 locomotives, advises that on certain engines in bad-water districts the Talmage type of blow-off is used.

The committee has no recommendation to make in regard to the number or where the blow-off cocks should be located. The number and location of blow-off cocks depend on the quality of water used.

Filling of Boilers—One member advises that they have had a number of side sheets cracked by filling through blow-off cocks located in the water legs. They did not state whether they used cold or warm water. They are now filling through the blow-off cocks located in the barrel of the boiler. Another member advises that they have had considerable experience with sheets cracking from the filling through blow-off cocks with cold water. They now fill boilers through injectors when using cold water. It seems to be the consensus of opinion of the members that it is most advisable to fill the boilers from the blow-off cocks in the water leg, providing warm water is used. If cold water is used it should be filled through the valve on top of the boiler or through the injectors, and the committee recommends that this practice be followed out.

Washing Out and Filling Up of Locomotive Boilers—The reports regarding washing out and filling up of locomotive boilers and the use of blow-off cocks were so at variance with what is generally considered good practice, the committee would strongly recommend the appointment of a special committee to report thereon.

Location of Fittings—Gage cocks and lower column cock should be located so that they will not come directly back of gusset plate or stay angles, and not to be located directly over arch tubes.

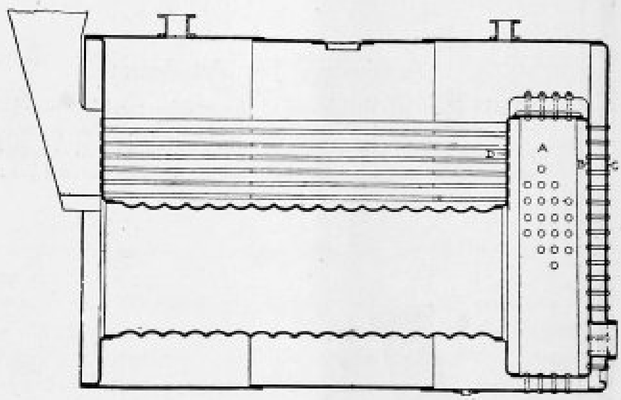
The report is signed by D. R. MacBain (C. R. I. & P.), chairman; C. E. Chambers (C. of N. J.), T. W. Demarest (Pennsylvania), F. H. Clark (B. & O.), R. E. Smith (A. C.L.), J. Snowden Bell and E. W. Pratt (C. & N. W.).

A Scotch Marine Boiler Explosion

Because of the small number of Scotch marine boilers in the United States it is comparatively rare that an explosion of one is recorded, and owing to this fact a layman often has the impression that this type is proof against explosion. That this is not the case, however, is shown by the following account of an accident to such a boiler which occurred at the plant of the Mt. Clements Sugar Company, Mt. Clemens, Mich., on Oct. 30, 1911.

The vessel was what is known as a "wet back boiler." The general construction of such a vessel is shown in the sketch. The tubes and flues terminate in an internal tube sheet *D*, and communicate with a combustion chamber *A* within the shell. The back of this chamber is formed by a sheet *B*, stayed to the rear head *C*. The space between sheet *B* and head *C* is filled with boiler water under pressure, and gives the name "wet back" to the type. It was the bursting of this "wet back" and the consequent collapse of the combustion chamber that occasioned the disaster. Its initial cause was the pulling off of sheet *B* from the 172 stay-bolts which held it.

An investigation disclosed the fact that the holding power of many of these stay-bolts had been greatly diminished by the buckling of sheet *B* between them, this buckling causing



SECTION OF WET BACK BOILER WHICH EXPLODED

the stay-bolt holes to take a conical shape with the larger diameter of the cone on the water-side of the sheet. This deformation of the hole disengaged the threads to such an extent that those remaining were unable to support the load imposed on them by the boiler pressure.

The boiler at the time of the accident was connected in line with seven others, on which all pop valves were set to 105 pounds per square inch, so there is a reasonable certainty that the pressure did not exceed this amount. The stay-bolts on sheet *B* were 1⅛ inches in diameter and spaced 7¼ inches apart each way, and the sheet was 15/32 of an inch in thickness. The only plausible explanation as to how a pressure which did not exceed 105 pounds could seriously buckle a sheet of this thickness held by stays in the manner described, is that the sheet was weakened by overheating.

From the data at hand the cause of this overheating cannot be definitely determined, but the boilers were reported clean, and if such was the case forced driving or low water was probably responsible. Sheet *B* was thrown forward against the rear tube sheet *D* with such force that it drove a number of tubes through the front head, some of them extending as much as 6 inches from its face. This was shown from the front of the boiler.

Three men were seriously scalded by this accident, one being so severely injured that he died shortly afterward. The property damage was chiefly confined to the boiler, with the exception of a brick wall located some distance in front, which was thrown down by the force of the explosion. The doors and hoppers of the boiler front were blown through a window 20 feet away.—*The Locomotive.*

New Shops of the New York Central Iron Works Company

BY L. L. RITCHIE

Some months ago the New York Central Iron Works Company moved its plant from Geneva, N. Y., to Hagarstown, Md., and erected there one of the most up-to-date boiler shops in the country. The plant is located north of the city limits on a 15-acre site. A switch from the Cumberland Valley Railroad passes directly through the shops, and the company has the right of way for other railroads to enter at any time.

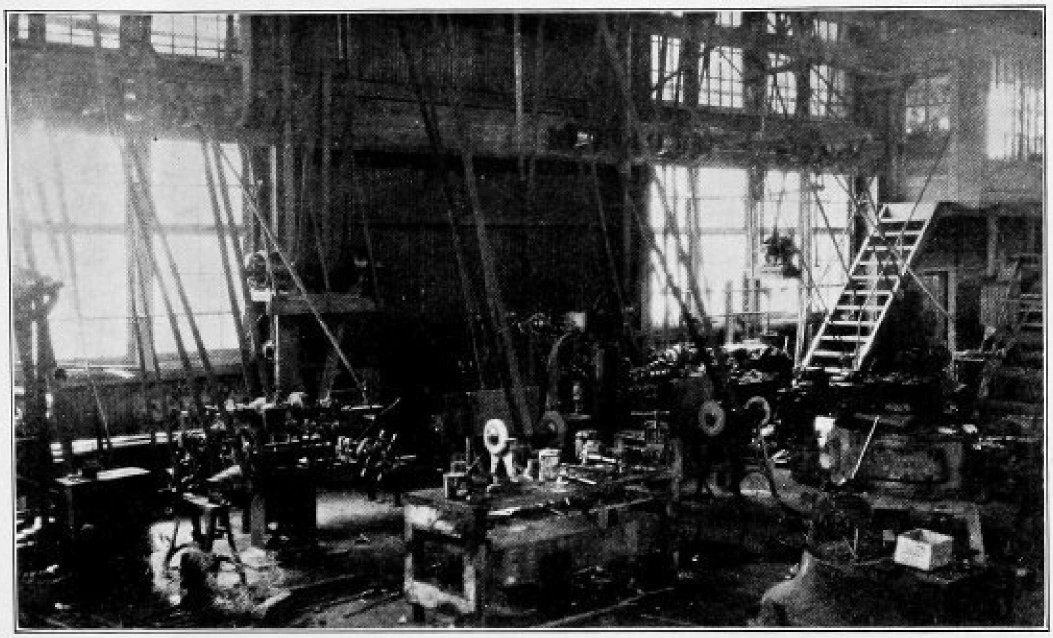


FIG. 1.—MACHINE SHOP FLOOR

The main building, shown in Fig. 2, is 252 feet long by 80 feet wide. At the extreme south end of the building the railroad tracks enter on a grade, so that all the cars are on a level with the floor line.

The shop has two bays; the one on the north side is 252 feet long by 30 feet wide. In the first 50 feet of this bay are located the plate storage racks. These racks are made by placing 3-inch I-beams in cement, letting them extend vertically about 7 feet with 12 inches from center to center of the beams. This allows plenty of room for storing the different sizes of plate without taking up much floor space. The plates are put in the racks by large plate tongs, which are hung on the hook of a 3-ton electric crane, which takes care of all the material coming in and transfers the plates from the racks to the layer-out and his assistants, who are located next to the plate racks.

Next to the laying-out bench is a rotary splitting shear, which has a 96-inch throat and a capacity of shearing 3/4-inch plate. From here, on passing down the bay, the next machines are the punches, which are on the north side and located 30 feet apart. Beyond the vertical punches on the

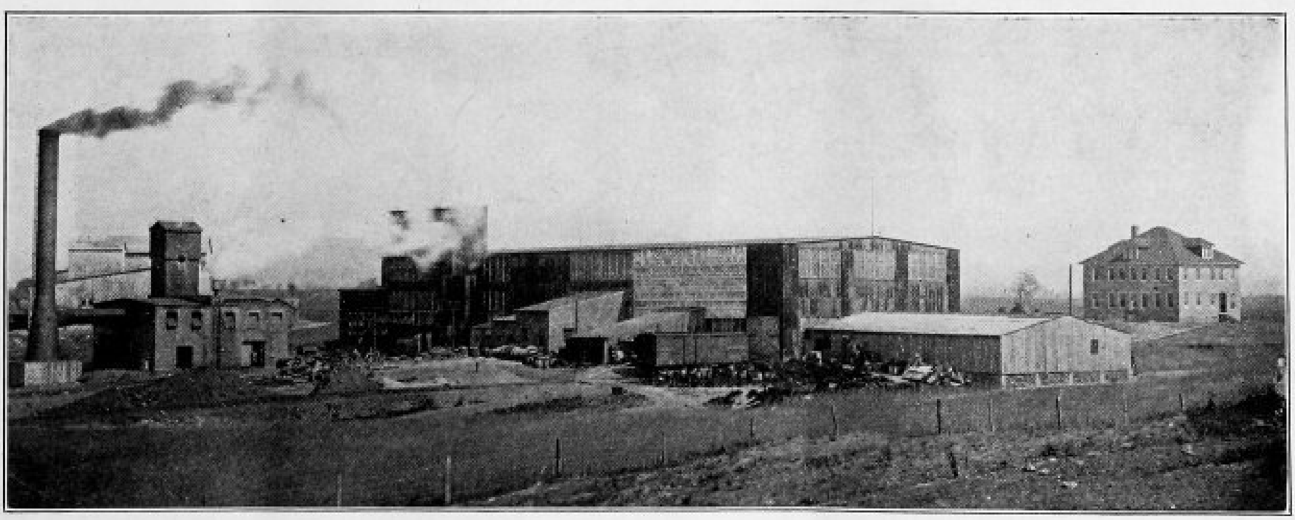


FIG. 2.—EXTERIOR VIEW OF NEW BOILER SHOP AT HAGARSTOWN, MD.

south side of the bay is a horizontal punch, while just below the vertical punches on the north side of the bay are the Lennox rotary bevel shears. At the west end of the bay is a set of 14-foot rolls; the upper roll being 14 inches in diameter and the bottom rolls 10 inches diameter. These rolls are located about 30 feet from the west end of the bay, and at the extreme west end of the bay is a rapid-action stake riveter for handling stack and light tank work. The work is taken from the rolls by a large jib crane, and transported into the main or 50-foot bay, where all the assembling is done. There is also at this end of the bay a 48-inch vertical punch, a set of light bending rolls, Lennox bevel shears, snip shears and a horizontal punch.

After the work is assembled it is taken to the hydraulic riveting machines, which are on the south side of the large bay. Here, also, is the flanging department, which is equipped with hydraulic flanging presses for the various kinds of flanging work which has to be done.

Upon leaving the hydraulic riveting machines work is distributed along the bay for the finishing operations. Here the riveting is done by air machines. About 200 feet from the west end of the bay is located the testing pit, 4 feet deep and 30 feet square, which is of a concrete construction. Seven pieces of work can be tested at the same time in the pit, a water pump being provided so that any pressure required can be obtained. After the tests are finished the water is emptied into the pit and pumped to a large receiving tank on top of the power house, which is located about 100 feet from the main shop.

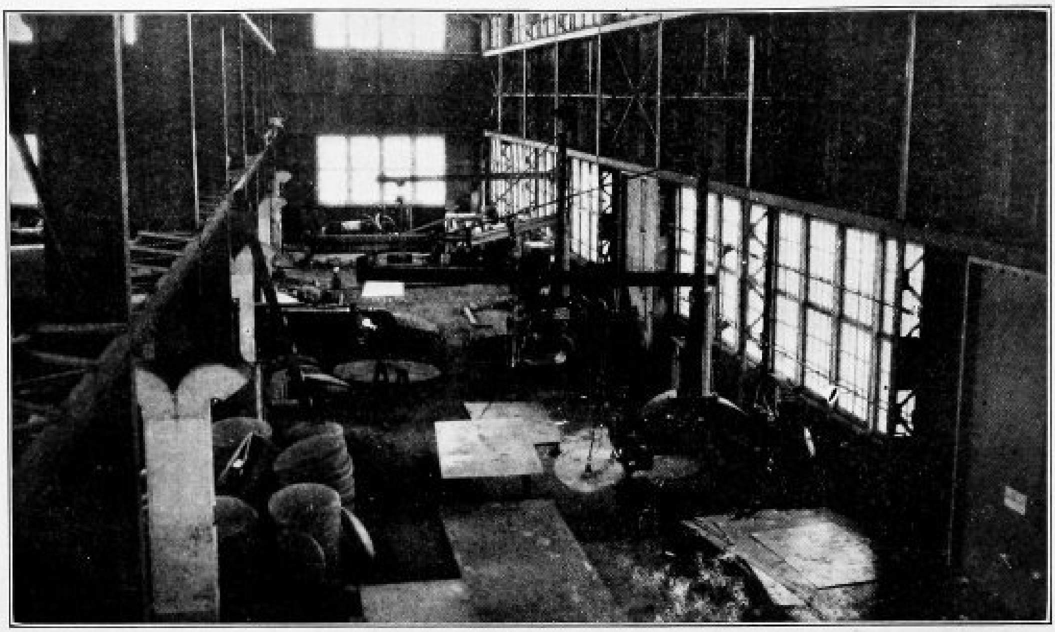


FIG. 3.—30-FOOT BAY IN MAIN SHOP

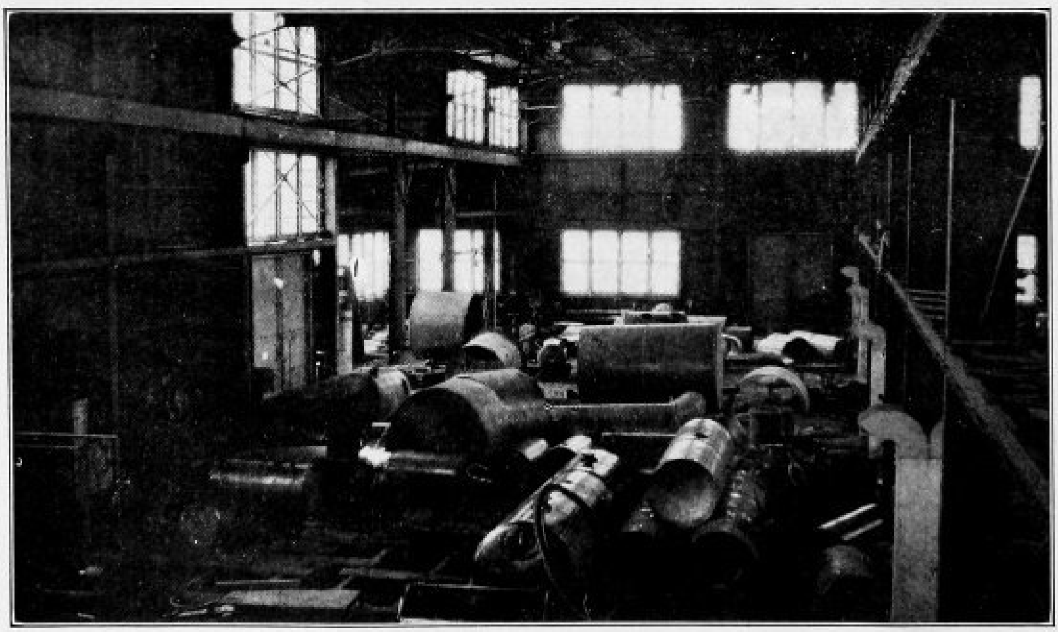


FIG. 4.—50-FOOT BAY IN MAIN SHOP

Besides the space allotted in the shops to the actual fabrication of the plate work, a machine shop is fitted up, occupying about 40 feet of the main bay at the east end, as shown in Fig. 1,

Steam for the power plant is furnished by two horizontal return tubular boilers, 72 inches diameter by 18 feet long, which are rated at 150 horsepower each. The steam pressure carried is 150 pounds per square inch. The power plant includes a 170-horsepower Corliss engine, an air compressor and receiver, and dynamo for supplying electricity for power and lighting purposes. All of the machinery is driven by individual motors.

The main shop has four large arc lamps and hundreds of small clusters of lights. The shop is heated with hot air from a fan-room and heating coils built expressly for this purpose. The hot air is fanned into large cement ducts under the ground and distributed through the shop by large rectangular funnels located, as shown in the photographs.

The office building is a large brick building, located about 150 feet north of the shop building. It has a floor space on the ground floor of 2,000 square feet, and has been equipped with all conveniences. There are large fireproof vaults on each of the three floors.

A Testing Tank

Some while ago a concern making pumping machinery were enlarging their testing plant. Among the new gear required was a 3,000-gallon tank, to be graduated for exact proportional measurement. The order for the tank was placed with precise instructions as to the necessity for exact graduations. The tank firm, after having the matter in hand some time, became aware of trouble. The tank was made square of 3/32-inch plate, and it was found that considerable errors existed, due to the bulging set up by the pressure of water when partly filled and completely filled. Upon acqainting their customer with the matter, the original order was insisted upon, and they must stay the tank so that it did not bulge.

Staying only minimized but did not obviate the trouble.

As an impartial onlooker the writer was amused at the correspondence between the two disputants.

Neither party to the order had given the shape of the tank a moment's consideration. It is obvious that if the tank were round all the trouble would have been avoided. The bottom, if mounted on a concrete base, would not have given at all, while the calibration of the tank per inch of depth would have been constant if the tank were reasonably made.

After the matter had reached the acrimonious stage, the shape of the tank did receive due consideration, and a round tank was substituted, with satisfaction to both parties.

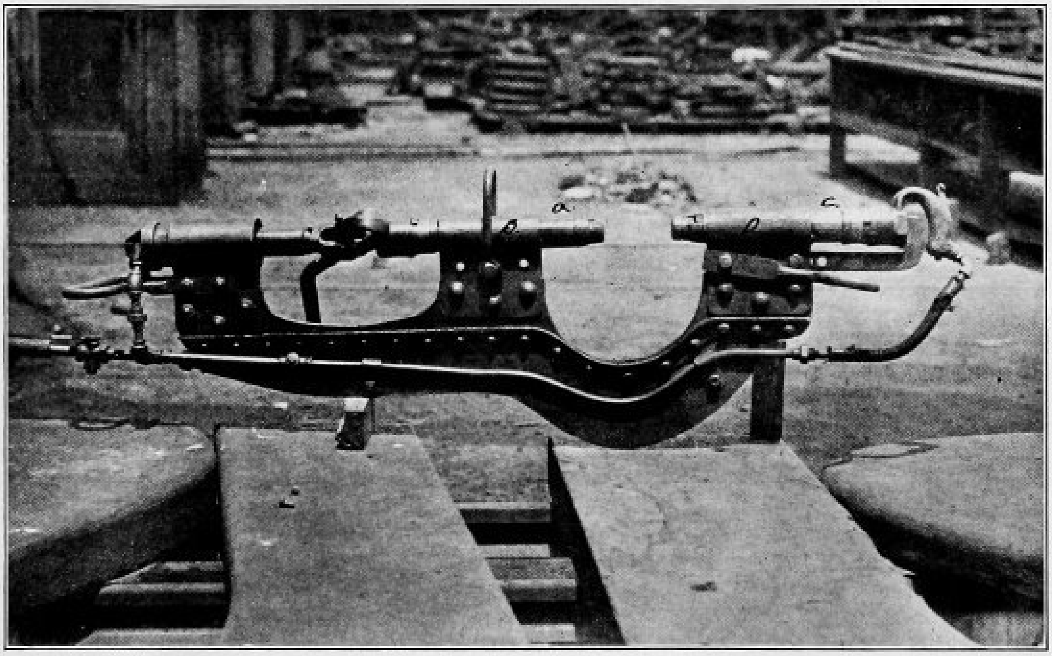
A small pinch of common sense would in this instance have saved much trouble. It should not be necessary to point out that a round vessel stays itself, but from the foregoing it appears that the fact needs emphasis once in a while.

London, England. A. L. HAAS.

A Shop Kink for Riveting Mud Rings

The accompanying photograph shows a shop kink made up of two pneumatic riveting hammers and a pneumatic holder-on arranged for riveting mud-rings. The holder-on forces the hammer *A* forward through the sleeve *B*, closing up on the rivet. Then when both hammers are put to work a very neat and tight job of riveting is done. Hammer *C* is adjustable in sleeve *D* to conform to the length of rivet. The frame is made up of ⅜-inch boiler steel stiffened with angle-iron, the weight of the complete apparatus being 220 pounds. The cut-out valve at the left admits air through the piping to all three machines at once, one hose furnishing air for all three machines. B. NICHOLS.

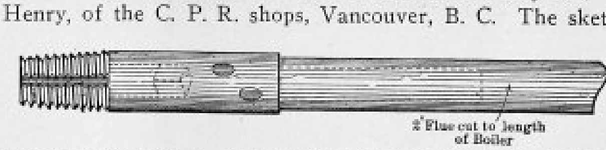
Piedras Negras, Mexico.



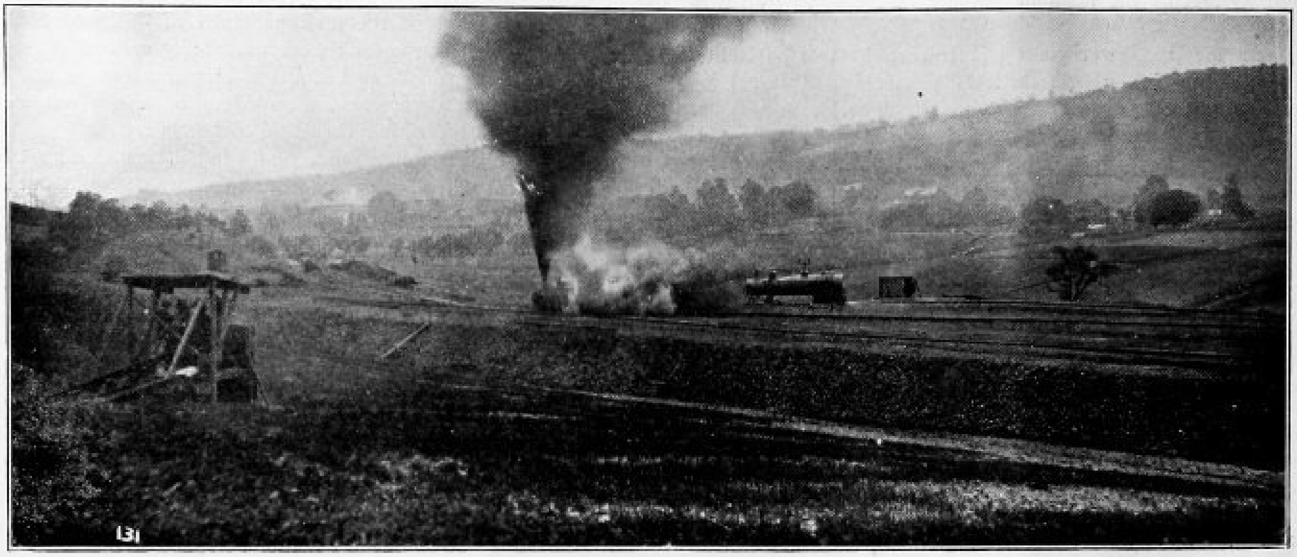
ARRANGEMENT OF PNEUMATIC HAMMERS AND HOLDER-ON FOR RIVETING MUD RINGS

A Useful Shop Kink

We show herewith a shop kink for tapping flue holes from the inside of a boiler, which has been contributed by Mr. W. Henry, of the C. P. R. shops, Vancouver, B. C. The sketch



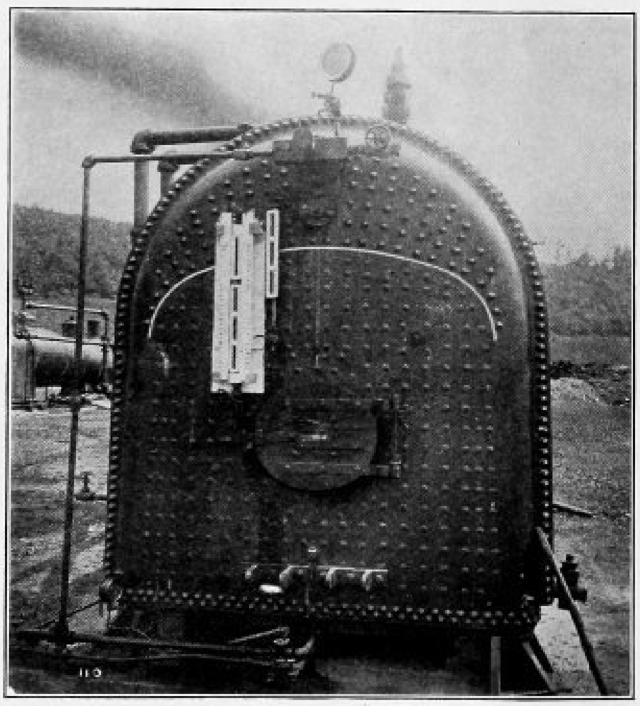
is self-explanatory. It should be stated, however, that the recess in the box wrench and where it goes into the tube must be a good fit. This device has proved quite a time saver and given good results.



EXPLOSION OF THE RADIAL STAY BOILER

Low-Water Tests of Locomotive Fire-Boxes

In the June issue of THE BOILER MAKER we published a brief account of the first series of comparative tests between a radial stay and a Jacobs-Shupert locomotive fire-box, as carried out for the Jacobs-Shupert United States Firebox Company, at Coatesville, Pa., under the direction of Dr. W. F. Goss, Dean of the College of Engineering, University of Illinois. The final tests in this series were made June 20, when the two boilers were subjected to severe low water tests. Both boilers were identical in size and design, except that one had a Jacobs-Shupert sectional fire-box, while the other had an ordinary radial stay fire-box. The principal dimensions of these boilers has already been given in our June issue.



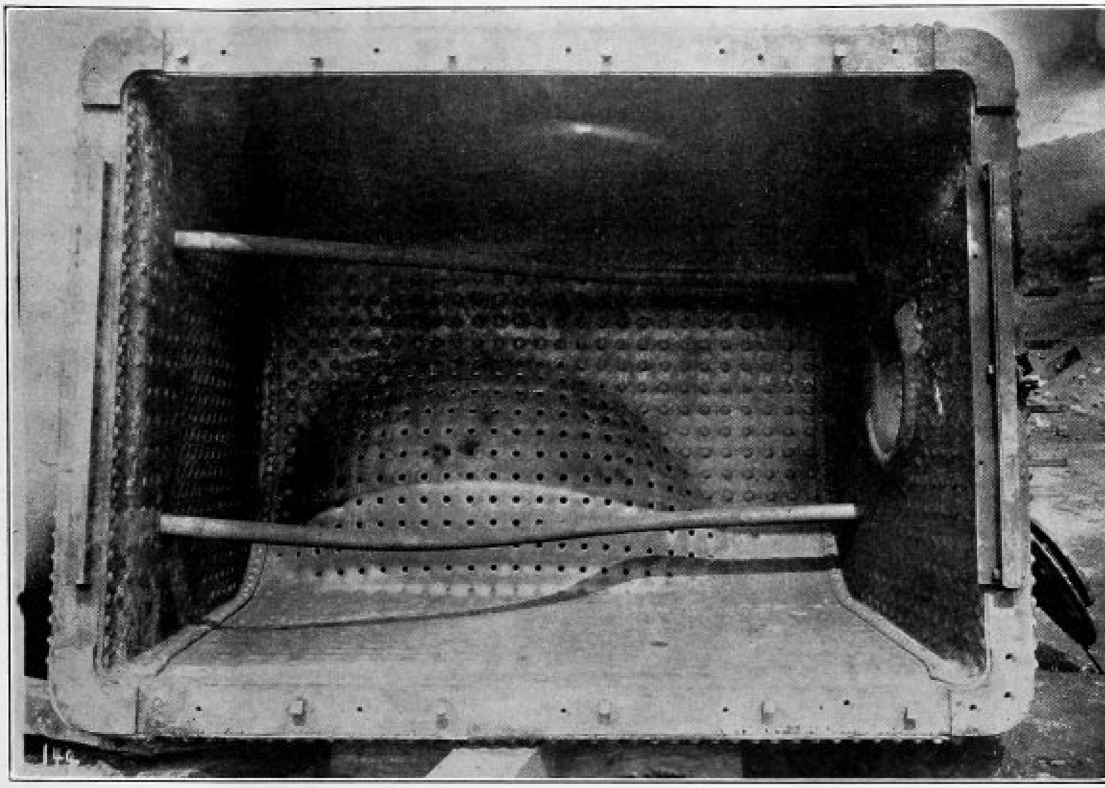
GRADUATED WATER GAGES ON BACK HEAD OF BOILER. THESE GAGES ARE READ THROUGH TELESCOPES ON TOP OF THE BOMB PROOF

For the purposes of these final tests both boilers were mounted 50 feet apart in an open field, where the results of an explosion could do no harm. The tests were controlled from a "bomb-proof" station, located 200 feet away from the nearest boiler. Oil was used for fuel, because of the danger to which a fireman would have been exposed shoveling coal. The oil was fed by gravity from an elevated tank to the burners. The steam generated was exhausted by the stack in the usual manner to produce the necessary draft, and any surplus steam was relieved by the safety valves.

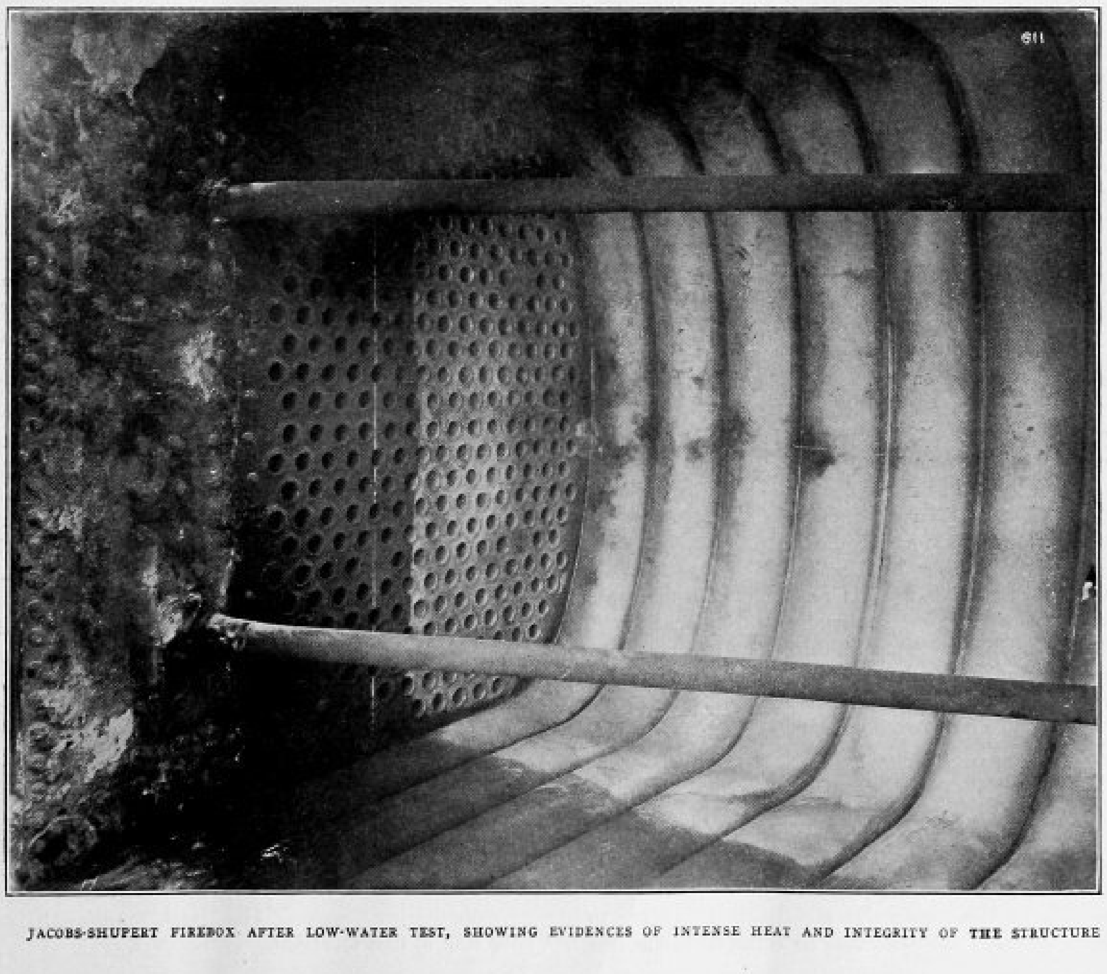
In the process of testing, each boiler was brought to a condition of operation closely approaching the maximum power, estimated to be at 1,400 horsepower, which is equivalent to that required to haul a heavy passenger train at a speed of 60 miles per hour. At the normal steam pressure and water level the evaporation was about 36,000 pounds of water per hour. After these conditions had been maintained for several minutes, the supply of feed water was then shut off, but all other conditions were continued unchanged. The water level, which was fully under control, was allowed to drop gradually, exposing the crown sheet and other portions of the heating surface to the full effect of the fire—just the condition which is supposed to have been the cause of many of the most disastrous locomotive boiler explosions.

The boiler having a Jacobs-Shupert sectional fire-box was continuously tested under these severe conditions for fifty-five minutes without developing any failure, notwithstanding the fact that the level of the water fell to a point more than 25 inches below the crown sheet. The water-gage glass did not reach below 25 inches, so the position of the water below this limit was, of course, not exactly known. The test was then discontinued because the small amount of water remaining did not evaporate sufficiently fast to supply the draft necessary to maintain the fire. At the conclusion of this test the Jacobs-Shupert fire-box was apparently in good condition and ready for further service.

The ordinary radial stay boiler was then tested under conditions identical to those above described. After the test of



INTERIOR OF RADIAL STAY FIREBOX AFTER LOW-WATER TEST, SHOWING FAILURE OF CROWN SHEET



JACOBS-SHUPERT FIREBOX AFTER LOW-WATER TEST, SHOWING EVIDENCES OF INTENSE HEAT AND INTEGRITY OF THE STRUCTURE the ordinary boiler had been in progress for twenty-three minutes and the water level had fallen to 14½ inches below the crown sheet, an explosion occurred. The crown sheet and the stays which held it in place, having become highly heated, pulled away from each other and released the pressure in the boiler. The discharge of steam was through the fire-box, and the force of the explosion, amid clouds of steam and smoke, was sufficient to throw parts of the furnace in all directions for a considerable distance and to lift the entire boiler, weighing 40 tons, several feet above its foundation. The damage to the boiler was such as to make necessary its reconstruction.

The steam pressure during the Jacobs-Shupert's test varied between 215 and 225 pounds for the first twenty-seven minutes, and gradually dropped thereafter until it reached 50 pounds at the end of the test. The steam pressure on the radial boiler varied between 220 and 230 pounds, being 228 pounds when the failure occurred.

These tests are of great value in demonstrating that it is possible to construct a locomotive boiler with a fire-box of sectional construction which can withstand safely the dangerous conditions of overheated crown sheets when low water occurs. Statistics show that an average of fifty locomotive boilers explode each year, causing a property damage of several millions of dollars, the loss of a hundred or more lives, and the injury of many persons, and in a large percentage of these cases the cause of the explosion is attributed to low water in the boiler and the consequent overheating and subsequent failure of the crown sheet of the fire-box. These demonstrations, therefore, of the immunity of the sectional fire-box from serious damage from such causes are considered to show that the dangers of disastrous explosion from low water can be practically eliminated.

These tests were made possible by the Lukens Iron & Steel Company, of Coatesville, who provided the money for carrying out the work. The final tests were witnessed by a great number of railroad men, government officials, engineers, scientists and boiler experts from many different parts of the country as well as abroad.

The Locomotive Maintenance Problem

The visitor at the locomotive shops of English railways may notice a practice which conduces greatly to economy and efficiency of locomotive repairs. He will see a number of complete boilers on hand for the different types of locomotives used by the road. For the most numerous types there may be five or six. When an engine comes in for heavy repairs, the old boiler is lifted off and a new one put in its place, so that the locomotive spends only a few hours in the shops, instead of the three or four weeks usual in this country.

There are some very decided advantages in this practice in addition to keeping locomotives continuously in service. Figuring the value of a locomotive's time on the basis of its share of the entire earnings of the road—which we believe to be the correct method rather than using the mere interest on the investment—the loss of time in the shops amounts to more than the labor and materials used in repairing. On the other hand, the expense of carrying on hand extra boilers is only the interest on the investment, and this is more than compensated by other advantages. Work done in a hurry, or under pressure of any kind, is expensive and rarely thorough. By taking time to repair and to build boilers, the work in the shops can be equalized, a smaller force is kept steadily employed without overtime, inspection can be made thorough, and everything runs smoothly. It is better for the men and better for the company. This is worth far more than the interest charge on extra boilers.

Any material reduction in the time which locomotives spend in the shops reduces the locomotive investment necessary to do the business of the road. In cases of emergency, such as the long-continued cold weather through which we have just been passing, or such a congestion of freight business as took place in 1907, the advantages of quick repair are enormous. The accumulation of crippled power at such times accentuates the congestion; and it not infrequently leads to placing orders for large numbers of new locomotives beyond the normal requirements of the road.

This facility of making repairs also removes to a considerable extent the temptation to keep locomotives in service when they ought to be undergoing repairs. Locomotive failures and breakdowns are enormously expensive, although the cost of delay and detention of traffic cannot be figured with mathematical exactness. One railway system which we know of has a considerably higher cost of locomotive maintenance than some neighboring roads with similar conditions. It ascribes this to the policy of keeping its power in first-class condition at all times, thus insuring regularity of service and decreased cost of operation, although at higher repair cost.

European locomotives are better built. They cost more, but they stay out on the road doing their work, instead of spending 20 percent of their time in the shops. Boilers are built so as to be interchangeable; one can be taken off and another put in its place, without making new attachments and refitting. American locomotive boilers are not built with such accuracy. It is doubtful whether on any given lot of locomotives supposed to be exactly alike an exchange of boilers could be quickly made. Such accuracy has not been deemed necessary, and as it is supposed, at least, to cost more money, it has not been aimed at. It is doubtful, therefore, whether with existing locomotives the English practice could be used. There is no doubt, however, that this lack of interchangeability is costing American railways an immense amount of money.

If there is to be no change in future practice the number of types of locomotives will continue to increase, and each engine will be, as now, an individual machine instead of a member of an interchangeable class. This is not the only cause of growing cost of maintaining them, but it is an important one. The way toward decreased cost of maintenance and increased efficiency of operation leading to reduced transportation cost, lies in reducing the number of classes of locomotives on a road, and complete interchangeability within the class. The argument that this would hinder improvement through invention and design is fallacious; though it would prevent an enormous amount of expensive experimentation which never pans out. We apprehend, also, that ultimately the cost of that accuracy which would be necessary to secure such interchangeability would not be as great as is now claimed. It would not involve "building a locomotive like a watch"—although there are many reasons for believing that the road of truest economy lies in that direction. Orders for fifty or more locomotives of the same type and design are not infrequent in ordinary times. It would be interesting to learn just how much more would be charged for the necessary accuracy, and what the final economic results of a fair and sympathetic trial of the foreign practice we have mentioned would be.—*The Railway and Engineering Review.*

The Technical Bureau of Economical Steam Production, of Rotterdam, Holland, has presented the University of Pittsburg with a valuable apparatus. The instrument, which measures the amount of heat lost in generating steam, is in charge of Prof. Robert Kennedy Duncan, director of the Department of Industrial Research. By collecting, during a period of twelve hours, samples of fuel gas from a furnace, the instrument indicates the average percentage of carbon dioxide and whether or not stoking is economical. The result is an accurate measure of the amount of heat lost in combustion. For years scientists have tried to convert fuel into heat with the least waste. The Dutch machine, it is said, is a long step in that direction.

The Boiler Maker

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Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

It may surprise many of our readers, as, indeed, it surprised us, to learn from the letter which we print in this issue from the Nashville Industrial Bureau that a city which boasts of a population of over 100,000, and which is rapidly developing its resources in industrial arts, should lack that most necessary and fundamental requisite in a manufacturing center—a boiler shop. With six hundred factories already in operation and with new ones being constantly added, Nashville certainly offers an attractive field either for the establishment of a new boiler shop or for the location of a branch from some successful plant elsewhere. We trust that the needs of this growing city will no longer be overlooked by the boiler-making trade.

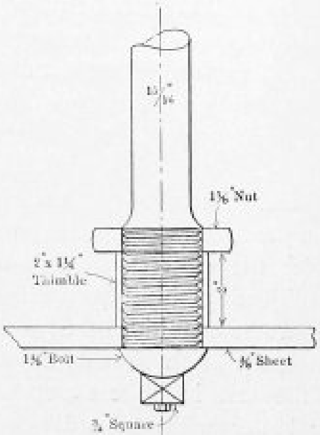
Low water is generally admitted as the most frequent cause of locomotive boiler explosions. With the usual construction, in which the firebox crown sheet is stayed by crown bars or sling and radial stays, it is well known that whenever the level of the water falls below the crown sheet and remains in that position for any length of time the crown sheet becomes overheated and the strength of its connections to the stays is diminished until they pull apart and the crown sheet collapses, although subjected to no more than the safe working pressure. This effect of low water has been fully recognized, but it was also realized that with the ordinary construction of fireboxes there were no means available for preventing the collapse of the crown sheet under such conditions, and consequently most efforts have been directed towards the prevention of low water. Any attempts in this direction, however, have met with only indifferent results, since as long as human nature is the controlling element in the operation of the boiler there can be no absolute guarantee of the maintenance of the proper water level. Recently, however, another element has been introduced, which, as shown by the low-water tests just conducted at Coatesville, practically offers safety under dangerous low-water conditions. This element is use of the new Jacobs-Shupert sectional firebox, which has proved to be practically immune from the dangers of collapse under the most severe low-water conditions. After subjecting this type of firebox to the most severe low-water conditions that would probably be met in practice, the boiler showed no weakness and came through the test in almost perfect condition, while a similar boiler with the ordinary radial stay firebox, subjected to virtually the same conditions, exploded, as was expected. On the plea of safety, then the sectional firebox deserves most careful consideration.

A report of particular value was presented at the Master Mechanics' Convention this year on the design, construction and inspection of locomotive boilers. The substance of this report is printed in this issue, and a digest of the discussion as reported in the DAILY RAILWAY AGE GAZETTE will be given in the next number. As the report presents a consensus of opinion derived from actual practice, it is worthy of careful study. Many of the points covered have been up for discussion at recent meetings of the Master Boiler Makers' Association, and so the conclusions reached do not differ materially from the findings of that body except in so far as they cover perhaps a wider field of experience than was available to the master boiler makers. Some of the recent changes in locomotive design have been quite marked, as, for instance, the increase in size, the general reduction of steam pressure, and the use of superheaters, liquid fuel and combustion chambers. Conditions of service vary so widely, however, that it is difficult to make any recommendations regarding design that will prove satisfactory in all cases, and consequently what few recommendations the committee felt justified in making are given with qualifications which should be given due consideration. A great many of our readers are well qualified to discuss this report and we hope they will send us for publication in future issues the results of their own experiences along these lines. The report, while extensive, is by no means exhaustive, and much more can be said to advantage on many of the subjects that have been only briefly outlined.

New Improved Engineering Specialties for Boiler-Making

The Handly Crown Stay

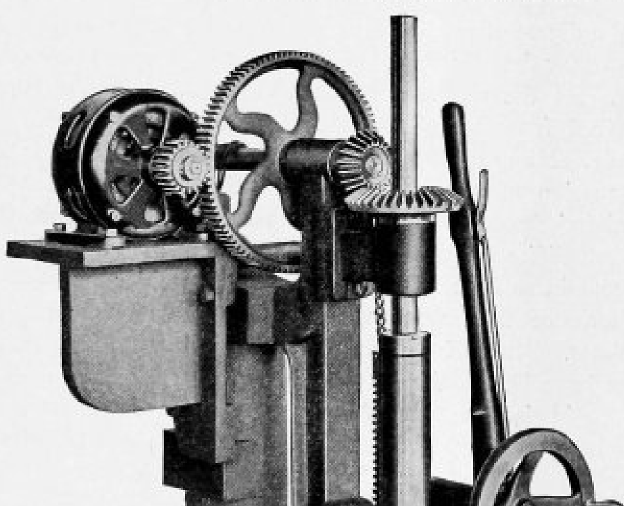
The accompanying drawing shows the Handly crown stay. These crown stays are the invention of Mr. A. J. Handly, Lovejoy, Ill., and are in use in St. Louis on the terminal railroad, where it is said they are cutting down boiler work in the



roundhouses 80 percent. The crown stay has a 2-inch thimble put on inside of the crown sheet, and a 1⅛-inch nut screwed down on the thimble to keep the vibration out of sheet and to protect the joint and stop the leaking.

An Overhead Motor Drill

Boynton & Plummer, Inc., Worcester, Mass., have placed on the market an overhead direct-connected motor drill. As can be seen from the illustration, when the drill is mounted

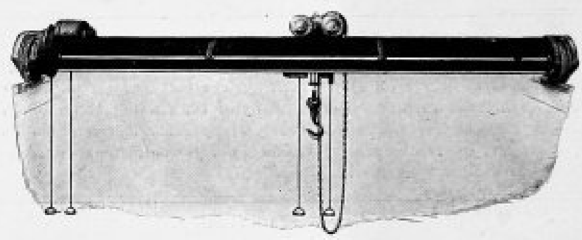


on a post or cross-head work of any dimensions can be accommodated. A ½-horsepower motor drives the spindle at any desired speed. The drill is also furnished with a four-step cone and countershaft. The length of the drill is 36 inches—19½ inches from the post to the spindle. There is a counterbalanced steel spindle fitted for Morse taper No. 3. In a boiler shop where a great variety of work is handled this drill should prove particularly useful, since it can be adapted to work of any dimensions.

Conbination Electric and Hand-Power Crane

A combined electric and hand-power crane for use in moderate capacities and moderate speeds has been recently placed on the market by the Northern Engineering Works, Detroit. The crane can be made in one, two or three motor designs. When any of these motors are omitted, a hand gear, operated by pendant hand chain, is substituted. In general use the hoist and bridge travel are operated by motors, although in some cases, especially when the cranes are of small capacity or short span, there is only one motor used, that on the hoist; the travel motions both being by hand.

The crane bridge is of the double girder type with the trolley traveling on top of the girders. The hoist is suspended from the trolley between the bridge girders. When the crane



is made for hand travel the axles are fitted with roller bearings lined in steel cages, but when designed for motor travel they are of bronze. The motors are of a type designed especially for the crane, and can be made in either direct-current or alternating-current style.

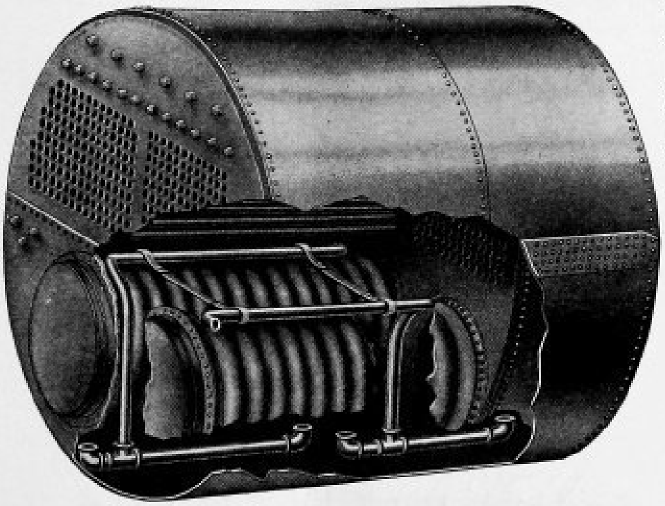
The hoist has enclosed gearing and can be bolted or attached to the trolley in such a manner as to permit its removal and use elsewhere if desired. Wire hoisting rope is used, gears are cut throughout and are enclosed for internal lubrication. An automatic stop prevents the hook from running into the drop. Hoisting and lowering are by power, and the load is automatically controlled and held in place by an unique enclosed automatic brake. The company also make the hoist used on this crane in a self-contained form which can be bolted to the trolleys of other cranes.

This crane is made in capacities ranging from 1 ton up to 6 tons, and the usual spans are from 10 feet up to 40 feet to accommodate the building in which they are placed. The cranes can be also devoted to outdoor work, and are especially well suited to service in cutting sheds, stone yards, show rooms, etc.

The cut shows a two-motor design, with hoist and bridge travel operated by motors and the trolley travel by hand. The hoist can be obtained separately when desired.

Eckliff Automatic Circulator

Practically the only handicap which is found in the Scotch type of boiler as a steam generator is the lack of circulation and the dead water below the grate level. To overcome this handicap the Eckliff Automatic Boiler Circulator Company, Detroit, Mich., has placed on the market a circulator which operates on the thermo-syphon principle. It is not a mechanical device but is governed entirely by the simple laws of gravitation and physics. The circulator, as shown by the illustration, consists of special tubing, so placed in the boiler that positive heat units are absorbed from the crown sheet of the furnaces, and the circulation of the water starts as soon as a hot fire is obtained in the furnace. A blind plug, which contains a thermometer, is placed at the lowest point in the boiler, so that a glance at the thermometer will show the temperature of the water at a point in the boiler which is usually filled with



dead water. With the circulator attached, however, it is claimed that a temperature of not less than 20 degrees below the temperature of the steam carried is obtained at the lowest point in the boiler, if the feed water is delivered at 125 degrees F. or better. The action of the circulator is entirely automatic; there is no wear and tear, and the only change in the ordinary construction of the Scotch boiler is to drill a single 1-inch hole in the shell to accommodate the blind plug for the thermometer.

Hollow Stay-Bolt Iron

In the purchase of stay-bolt iron for locomotive fire-boxes it is desirable that it shall meet the various tests specified for strength and endurance under vibration as well as the requirements of the Federal boiler inspection rules. Falls Hollow stay-bolt iron, manufactured by the Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, has been frequently tested as to tensile strength requirements, and found to exceed them in elongation and reduction of area, which indicates unusual ductility, the valuable quality desired in stay-bolt iron, and which enables this particular iron to far exceed the requirements of the vibration test. The specifications now in general use are those adopted by the American Society for Testing Materials, and these require a strength not less than 48,000 pounds per square inch, not less than 28 percent elongation in 8 inches, and a reduction of area not less than 45 percent. While Falls Hollow stay-bolt iron may sometimes not exceed the limit for ultimate strength, the elongation in 8 inches in such cases is said to be always 32 to 35 percent, and the reduction of area as high as 58 to 60 percent. The vibratory tests in the same specifications require that the test bar shall endure a minimum of 6,000 revolutions when a threaded specimen fixed at one end has the other end moved in a circular patch while under a tensile load of 4,000 pounds. The circle described shall have a radius of 3/32 at a point 8 inches from the fixed end of the specimen. Seven samples of Falls Hollow stay-bolt iron were tested under the above conditions at Purdue University, and the average number of revolutions required for rupture was 10,738. One sample endured over 13,000 revolutions and three over 10,000, while the lowest one required 8,339. The double bending test requires that the bar shall be closed in both directions without flaw. The illustrations show how well the Falls Hollow specimen has met this requirement, as well as the more severe test by bending after the specimen was threaded.

Fig. 1 represents a bar 1⅛ inches in diameter, bent cold flat on itself and retaining a smooth surface with no rupture. The extreme ductility of this iron is shown by the distance the molecules had to float without rupture in following the curve described in bending the bar.

Fig. 2 represents a bar 1⅛ inches in diameter, nicked 1/16 inch deep one-half way around and bent flat on itself to produce rupture and show the fibrous structure of the iron and the stretch at the hollow portion. It also shows the standard V thread, 12 per inch, when bent flat on itself. Although each thread is the equivalent to the nick which ruptured the other

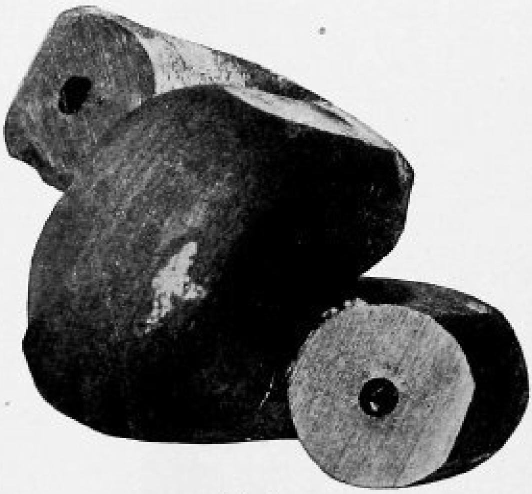


FIG. 1

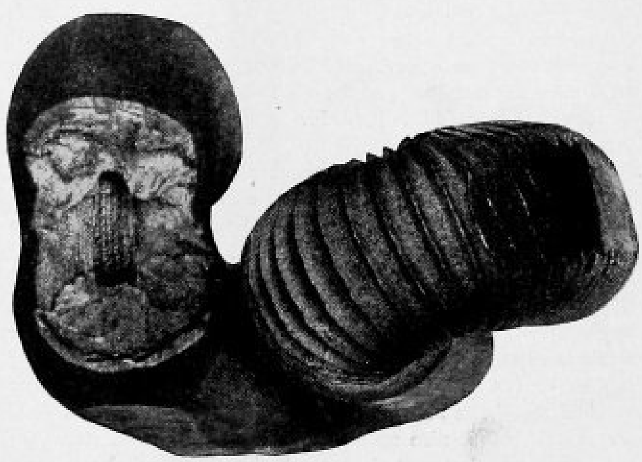


FIG. 2

end, no rupture is readily apparent, there being very minute ruptures at the base of every thread, thus demonstrating the complete uniformity of the fibrous structure.

The advantage of the hollow feature of this material is of special interest since the passage of the Federal Boiler Inspection Act, as the rules adopted for the enforcement of that act have certain requirements which are most easily and economically met by the hollow stay-bolt iron. One of these rules requires that all stay-bolts shorter than 8 inches applied after July 1, 1912, except flexible stay-bolts, shall have tell-tale holes 3/16 inch in diameter, not less than 1¼ inches deep in the outer end, and these holes must be kept open at all times. As is well known, the Falls Hollow stay-bolt iron has 3/16-inch holes clear through, so that the time and expense required for drilling every stay-bolt is avoided by the use of the hollow bolt. The use of the small hole in the stay-bolt is to detect fracture, which almost always occurs near the outer sheet, and it is necessary, therefore, that the holes be kept open. A stay-bolt with the hole clear through, it is claimed, will be kept open with certainty by the draft passing through it with every exhaust of the engine, and with fire or light inside the fire-box it is easy to see at a glance that the hollow stays are open, while the hole in the solid bolt requires individual inspection in order to ascertain that the hole is open to the required depth. The hole in the hollow stay-bolt is kept clean to a large extent by the constant passage of air through it when the engine is working, and there is a draft from the fire-box through the tubes. The vacuum, which is sufficient to draw air through a thick bed of hot coals on the grate, will also cause an active current through the holes in hollow stays, and this is sufficient to clean out most of the dirt which stops up the drilled holes in other stays. This certainty of a clean hole in the hollow stay renders it a safe check on broken stays, and it is a valuable feature in view of the rigid requirements of the Federal boiler inspection rules, which state that no boiler shall be allowed to remain in service when there are two adjacent stay-bolts broken or plugged, nor when three or more broken or plugged stays are found in a circle of 4 feet diameter, nor when more than five broken or plugged stays are found in the entire fire-box.

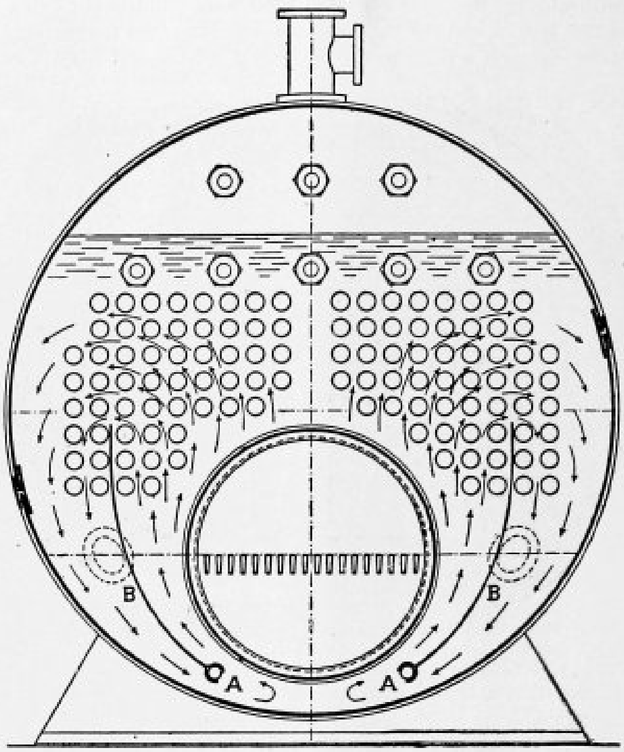
The value of an admission of air in the fire-box above the grate to prevent smoke and secure complete combustion has long been recognized, and hollow ferrules in the sides and ends of the fire-box, with steam jets, were for many years regarded as efficient smoke preventers. Another method quite generally used was to drill $\frac{3}{8}$-inch holes in many of the stay-bolts in the sides of the fire-box for the purpose of securing an air supply above the fire, in order to obtain more complete combustion, and they were undoubtedly quite effective in producing that result. The hollow stay-bolt supplies an equal or greater amount of air to the hot gases and, it is claimed, in a much better way. The jets are so finely divided that they have an opportunity to become highly heated soon after entering the box, and the air is then in proper condition to supply the needed oxygen for complete combustion of the gases.

In addition to these advantages there are others found with the hollow stay-bolt, due to the fact that the 3/16-inch hole is central in the bolt and the bending stresses do not reach a point where there is no material to resist them. Most drilled stay-bolts are eccentric, and with the hole to one side the bending strength of the stay is not as great as with one having the hole truly centered. With drilled stay-bolts the work is often done so carelessly that the hole is considerably out of center, and it is reasonable to conclude that many cracked stay-bolts are due to this cause. The central hole of the hollow bolt is also an advantage in drilling out stays, for the large drill does not then reach the sheet and destroy the thread required for a tight stay.

Falls Hollow stay-bolt iron is made from double refined charcoal billets, and the long experience of the works in making this grade of iron as a specialty enables them to produce it in a very uniform quality, so that test samples may be considered to really represent the whole amount in any shipment.

The Copeland Patent Automatic Circulating System

The automatic circulating system for Scotch boilers, patented by the F. T. Copeland Company, New York, consists of two rectangular plates of steel or other metal, of such length as to extend from head to head of the boiler, and of such width that when in position they will extend above and below the grate level or fire line. They are erected edgewise upon suitable means of support located below the grate line. The plates are curved to correspond approximately with the radius of the furnace. They are designed to reach from a point near



Tubes A A support plates B B and supply hot air to combustion chamber.

the center of the bottom of the boiler, to an indeterminate point above the bottom course of fire tubes. Tubes *AA* support plates *BB*, and incidentally supply hot air to the combustion chamber. Each plate becomes a partition which subdivides the space between the furnace and the shell, so that a pathway is provided for an uprising current on the inside, due to the heat from the furnace, and a down-flowing current on the outside, due to the greater density of the cooler water. Therefore it is claimed that the circulator establishes and maintains natural and complete circulation throughout the boiler; beginning immediately upon starting fires, and operating automatically and continuously until the fire is extinguished. The further advantages are claimed of increased horsepower capacity by causing the entire water contents of the boiler to travel over the heating surfaces; equalized temperature; improved combustion due to the admission of hot air to the combustion chamber, and improved boiler efficiency from the cleansing action of rapid circulation over the heating surfaces. This system can be applied to one, two, three or four furnace boilers.

The San Antonio Boiler & Iron Company, San Antonio, Tex., recently incorporated, with a capital stock of $15,000 and $10,000 paid in, is about to move into a new plant, which, according to *The Iron Age,* will cost $8,000. The new shop is 60 feet by 120 feet and 20 feet high. The company is engaged in a general boiler and machinery business. John M. Wilson is president and H. C. Ruth, vice-president.

Mr. John Cook, of Springfield, Ill., a well-known and valued contributor to this magazine, writes us that the month of June this year completed his sixtieth year in the boiler-making trade, which establishes a record of faithful service that we believe is rarely exceeded if ever equaled.

Communications of Interest from Practical Boiler Makers

Nashville Offers Opportunity

You probably do not know it, but it is a fact, that Nashville has no boiler shop. We do not know of another city of more than 100,000 inhabitants which has no boiler shop. Considering the facts that we have about 600 factories here, that new factories are being constantly established, and that Nashville is a very large buyer of boilers, it does seem to us strange that no company sees its way clear to establish a boiler shop here. We are offering one of the greatest opportunities for an establishment of this kind that can be presented in the whole length and breadth of the nation. It occurred to us that you probably know of some boiler factory that desires to change location or one that would like to establish a branch factory in a desirable location. In either event Nashville is the place.

NASHVILLE INDUSTRIAL BUREAU.

Nashville, Tenn.

Use of the Measuring Wheel

I have been much interested in Mr. Havlak's contribution in the May number in regard to the measuring wheel. I was of his way of thinking when I was younger, but got over it bravely, and have used the wheel a good deal, always for measuring heads or inside of courses—in fact, anything that was rolled up—but I measure the plate or sheet with the wheel, too. The wheel is supposed to be laid off into inch spaces up to 24, but it doesn't always come out right in a number of revolutions, so that it won't do to measure the sheet with a rule or tape line according to the measurements given by the wheel. The wheel must be used for the sheet as well as for the course or head. If an outside course is wanted add to the measurement three times the thickness of metal; if for an inside course deduct three times the thickness of metal. This comes good for either wheel or tape line, and there will be a good, tight fit. Some allow 3 1/3 times the thickness for an outside course and deduct 3 1/3 times for the inside.

JOHN COOK.

Springfield, Ill.

A Correction

Referring to the table on page 176 of THE BOILER MAKER for June, 1912, giving the area of stay-bolt, etc., I note what appears to be a typographical error in the first three columns, caused by failure to place the figures in their proper order. I would suggest that a corrected table be printed in an early issue to guide those who would follow the same in compiling specification cards. I give below a corrected form of table from 1 inch to 1 5/32 inches, which covers the figures in question:

TABLE 2. AREA OF STAYBOLT, ROOT OF THREAD, LESS TELLTALE HOLE.

Diameter Inches.	Decimal Equivalent Inches.	Area Inches.	Diameter at Root of Thread, Inches.	Area at Root of Thread, Inches.	Area at Root of Thread Less Telltale Hole Inches.
1 1-32	1.03125	0.83527	0.88692	0.6178	0.5902
1 1-16	1.0625	0.8866	0.91817	0.6622	0.6346
1 3-32	1.09375	0.9375	0.94945	0.7079	0.6803
1 1-8	1.1250	0.9940	0.98067	0.7554	0.7278

A more elaborate table is now in course of preparation which will give the final stress at pressures ranging from 110 to 240 pounds and spacings from 4 by 4 to 6 by 6, and this will be available for publication in an early issue.

Washington, D. C. ROY F. CARTY.

A Template Rack

Any layerout knows how tiresome it is to hunt through a large pile of templates, often kept on a pile under a pair of trestles or under a work bench, and the one you are looking for is always at the bottom; then you have to put them all back again, and this takes a great deal of time and work. With the rack here shown all this work is done away with, as your patterns are as pages in a large book, and any one can be pulled out or put back independently.

Cut a piece of 10-inch channel about 6 feet long, or to suit the size of templates; any old scrap channel will do. Make two U-shaped pieces high enough to exceed the width of your widest template, and wide enough to fit outside the channel, as shown in the end view (Fig. 1). Make two pieces 24 inches

FIG. 1

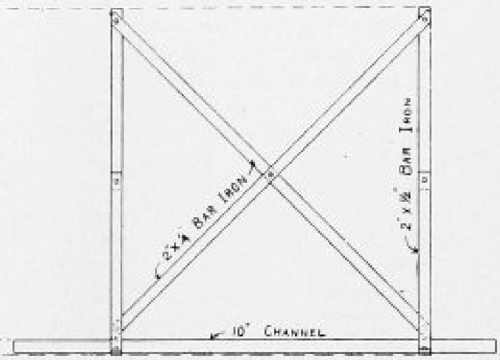


FIG. 2

long and rivet them across under the channel as shown. Rivet the U-shaped bars in the same location as shown in Fig. 2. Make four bars for the side braces shown in Fig. 1; all rivets to be countersunk inside the rack as shown. The diagonal braces are put on one side only, and serve as a back for the patterns to lean against. These could be substituted by a piece of old tank steel to cover one whole side of the rack, and the small patterns would never fall out.

Anyone making this rack will be surprised at how little space it takes up. It can be set at the side of the punching machine, and will keep anything from flying into the gear wheels. As the patterns set on edge, they can be paged over like leaves in a book, and titles of patterns can be stenciled on the near edge. Always put in your patterns so you can see the title, and you will have easy work of finding any one you should need. A smaller channel can be used to suit the number of patterns.

PHIL. NESSER.

A Table of Multiples for the Practical Convenience of Those Who Have Occasion to Refer to Mensuration

Diameter of a circle × 3.1416 = circumference.

Radius of a circle × 6.283186 = circumference.

Square of a radius of a circle × 3.1416 = area.

Square of a diameter of a circle × 0.7854 = area.

Square of the circumference of a circle × 0.07958 = area.

Half of the circumference × half of the diameter = area.

Circumference of circle × 0.31831 = diameter.

Circumference of a circle × 0.159155 = radius.

Square root of the area of a circle × 1.12838 = diameter.

Diameter of a circle × 0.86 = side of an inscribed equilateral triangle.

Circumference of a circle × 0.225 = side of an inscribed square.

Diameter of a circle × 0.7071 = side of inscribed square.

Circumference of a circle × 0.282 = side of an equivalent square.

Base of a triangle × one-half the altitude = area.

Diameter of a circle × 0.8862 = side of an equal square.

Multiplying both diameters and .7854 together = area of an ellipse.

Surface of a sphere multiplied by one-sixth of its diameter = its volume.

Circumference of a sphere multiplied by its diameter = its surface.

Square of the diameter of a sphere × 3.1416 = its surface.

Cube of the diameter of a sphere × 0.5236 = its volume.

These are a few rules that were in my "Rithmatic" when I was going to "Skule" studying the three R's. JOHN COOK.

Springfield, Ill.

A Suggestion for the A. B. M. A.

The writer has read with a great deal of interest an article in the May issue of THE BOILER MAKER, page 157, which is a comment on the A. B. M. A., and signed "Progressive." I wish to go on record as being in full accord with what the writer has said. It seems to me that the manufacturers of boilers, tanks and other heavy steel plate work ought all to be active members of the American Boiler Manufacturers' Association, and also that at least one day of each convention should be devoted to the subject of "profit." Personally, I believe that more boiler manufacturers would join the association if a good, thorough discussion of this subject was had, which would be of great benefit to all manufacturers present. There should also be a good local organization in each large city where there are several shops, as it is here you will find existing many things that would never be tolerated in other lines of business where the interests have a local organization.

It is not necessary to violate any law in the least to find a proper method of giving to the boiler manufacturers what they are justly entitled to—that is, a fair return on their investment and a fair recompense for their services. I may be entirely wrong, but I believe that the greatest trouble with the boiler manufacturers is that most firms do not know what their cost of production is. The writer personally recalls a conversation had in our office a few years ago between the founder of this business (Daniel Connelly) and another boiler manufacturer, who had just failed for the second time within a few years, and who, when too late, came for advice as to what was the trouble that he did not succeed. My father's first question was: "How do you estimate your work?" and the reply was, "We estimate carefully the material needed to build the job, figure out carefully what the labor ought to be, make a total of these two items, and add 10 percent for profit." My father then said to him: "You have answered your own question, as the margin of profit you have been figuring does not begin to cover your 'burden' or 'overhead expense.'" He had never heard of this term, and wanted to know what it was. When questioned as to the total amount he expended a year for coal, waste, oil, taxes, building repairs, machinery repairs, office help, telephones, interest, discount, horses' and wagon up-keep, bad accounts, insurance, his own salary, depreciation, etc., he had no idea as to what they amounted to, and they had never been considered. I personally believe that this is the reason why this line of industry has not been as profitable as other branches of the "iron and steel" business.

As the next convention of the A. B. M. A. is to be held in this city, I am going to suggest to those who will be in charge of that affair that a day be set aside for a full discussion of this subject. It may be that there are among our members some firms who feel that they have a very good system of "cost," and who will feel that they do not want to tell their competitors of what their system is. This I feel is a mistake, for the reason that if you can show a competitor that he is bidding too low on work it will be for the welfare of all if you can show him that it is necessary to raise his price or make a failure.

Among the other things that should be discussed is the "day rate" for various sizes of punches, rolls, hydraulic tools, etc., on repairs and other work requiring their use. Some people in every community have an idea that simply the day rate for the operators of these tools is all they should pay, and no charge for the use of the tool. I have personal knowledge of a machine shop charging $20.00 per day for a boring mill and one man, and this tool cost no more than a modern hydraulic riveter with its accumulator, pump and crane.

I recently attended a lecture on "cost keeping," given before the Cleveland Chamber of Commerce by the president and manager of the largest paint and varnish manufacturing company in the world. It was illustrated with charts, and their entire system of cost was given. A few months previous he had given this same lecture before his competitors at the convention of paint and varnish manufacturers.

The suggestion made by the writer of the article in your May issue, that all come to the Cleveland convention and submit their ideas as to the solution of this problem, is in my judgment a very good one, and I have above offered my suggestion. I shall be glad to hear from other manufacturers, either directly or through THE BOILER MAKER, and hope that the next convention will be the largest and most profitable one, as well as the silver jubilee, of the association.

Cleveland, Ohio. W. C. CONNELLY,

President, The D. Connelly Boiler Company.

Something for Young Boiler Makers to Read

If young boiler makers act on my advice, and take up the study of any subject, they must use care in selecting the book from which to study, as it seems to me that many authors give definitions which would discourage many at the very start, and this often accounts for a student feeling that he cannot understand the subject. I give an illustration of what I mean. In a book on plain geometry I find this:

"A straight line is a line such that any part of it, however placed on any other part, will lie wholly in that part if its extremities lie in that part." Now in the name of all that is possible no blinder definition could be given for the average mind. Here is a definition of a straight line which seems to me to be within the mental capacity of most boys and men:

"A straight line is the shortest distance between two points."

A book starting out with the first definition would not be likely to get any clearer as it goes on. What I said about trigonometry being easy to understand is true, provided the subject is not tangled up in a lot of words. What I am going to tell you about this study is by no means a thorough exposition of the entire subject, but I hope it will so interest you that you will "get going," and that you will take the subject up and master it.

Let us go a little deeper into this right-triangle business. We saw in my last talk that the length of the hypotenuse could be easily found when we knew the lengths of the two other sides; that is, by adding the squares of the two sides and taking the square root of this sum. We can therefore find the length of the short side, which is called the "opposite side," when we know the length of the hypotenuse, and the length of the long side, called the "adjacent side." We square the hypotenuse and the adjacent side and subtract the lesser from the greater, and take the square root of the remainder, and that result will be the length of the opposite side or short side.

Now if we want to get the length of the "adjacent," or long side of the triangle, we square the hypotenuse and the short or opposite side, subtract the lesser from the greater just as we did before, and take the square root of the remainder, and we have the length of the adjacent or long side. If we call the three sides of the right triangle *a*, *b* and *c*, *a* and *b* being the short sides and *c* the long side, we could then write the three conditions of getting the lengths of the three sides of the triangle mathematically this way:

Length $a = \sqrt{c^2 - b^2}$.

" $b = \sqrt{c^2 - a^2}$.

" $c = \sqrt{a^2 + b^2}$.

This sign $\sqrt{\quad}$ is used in mathematics to show that the square root of the numbers under its tail is to be taken; the small figures, just a little above the letters, are called "exponents," and they mean that the figure just in front of it is to be squared.

To put this in figures, which many understand better than when letters are used, we would have for *c*, when the short sides are 16 and 8, respectively, as was shown in the diagram in the May number,

$$c = \sqrt{8^2 + 16^2}, \text{ or } \sqrt{64 + 256} = \sqrt{320},$$

and the square root of this number is found from the tables to be 17.87. If, now, the exponent 2 was changed to 3 it would mean that the figure 8 was to be multiplied three times together; that is, $8 \times 8 \times 8 = 128$, if the figure was changed to 4 the 8 must be multiplied four times together. This would be called "raising" the figure 8 to the second, third and fourth "powers." All this is very easy to understand, and the square root sign is therefore not such a scarecrow after all.

To drop the mathematics for a while and get into the actual shop work, I had this put up to me by a man who was drilling a lot of holes (piece work) in a boiler drum for a small tube boiler. He was, of course, using high-speed steel and punching the drill through the metal in great shape, making everything smoke, but he was constantly troubled by having the drills pull out of the socket when they broke through. He tried putting a pin in the drill tang just where it showed through the slot, but this gave him trouble, as it was hard to get out, and he reported trouble in drilling the small hole in the drill tang. I told him to take his drill and grind off its cutting edge, so that there would be a straight instead of a bevel edge. After cutting off the metal and making this flat a full 64th, he reported no further trouble. Have any of the readers ever tried this dodge?

Speaking of drilling, and doing it fast, a friend told me he had seen a ½-inch drill put through a piece of cast iron 12 inches long in a little less than one minute. That I call drilling "some." The hole was not very smooth, but it was good enough to ream to a good hole.

Some of my machinist friends think I was pretty rough on them in my last month's remarks; but am I not right in saying that it is far too generally believed that boiler making is not an art, but main strength and awkwardness? I consider that far greater skill is demanded to-day in producing a modern boiler than twenty years ago, while the skill of a machinist has been lessened by tools which are far more accurate and practically automatic in their action. Of course, the boiler maker has pneumatic tools for chipping, etc., and he can do more work with them in a day than he can by hand, but it takes just as much skill to turn a flange as it ever did or to properly calk a seam, no matter whether the blow is given by air or a hand-hammer.

But I never heard of a boss machinist convention where the detail work of the trade is discussed, yet the boiler makers have had such a convention for years, and no man wants to go there and "talk through his hat"; they are about as practical a lot of men as is to be found, and they don't mince matters when they want to know; they won't accept anybody's "say so," they have to be shown. Every man who goes to these conventions comes back with more knowledge than he took with him, and the convention is not made up of narrow-minded men, but they take a good, wide look at things and give information as freely as they absorb it.

I want young boiler makers to aim to be one of those who go to these conventions in the years to come, yet I don't want them to get discouraged because they are not made foremen. A first-class boiler maker is an honor to his craft, and there is not such a lot of them ever to be found. If you can't go to these meetings be sure to read all about them in THE BOILER MAKER. F. ORMER BOY.

Length of Stock for Rings Made of Angles and Tees

I was specially interested in the rules given by Mr. Havlak in the April BOILER MAKER relating to the length of stock for rings made of angles and tees. The question of calculating stock where it is to be distorted considerably in forging is a puzzling one for many mechanics, and I would like very much

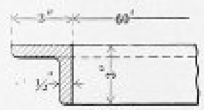


Fig. 1

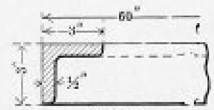


Fig. 2

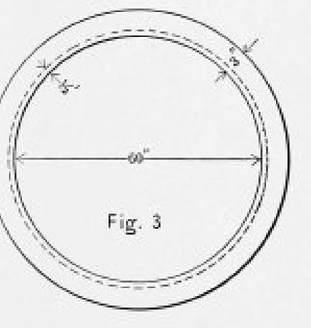


Fig. 3

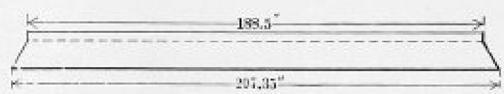


Fig. 4

to see the rules and practices of quite a number of boiler makers aired in these columns. In order to start the discussion, therefore, I would like to inquire as follows: Why assume a diameter measured to one-third of the flange, or to any other fraction thereof? Why not cut the stock to the actual dimensions of the finished ring, and add to this an amount equal to the distortion as actually found by experience? How will these rules of thumb, for such they are, test out for rings having a large diameter as compared with rings having a small diameter?

For example, take the first rule in the article referred to, and apply it to a 60-inch ring, using ½-inch by 3-inch stock. Here the length of stock, exclusive of the welding allowance, is by the rule for Fig. 1 equal to

$$\left[D + \left(T + \frac{W}{3}\right)\right] \times 3.1416,$$

or

$$(60 + ½ + 1) \times 3.1416 = 193.2 \text{ inches.}$$

With the flange as in Fig. 2 the length of stock equals

$$\left[D - \left(\frac{W}{3} + T\right)\right] \times 3.1416,$$

or

$$\left[60 - \left(1 + \tfrac{1}{2}\right)\right] \times 3.1416 = 58\tfrac{1}{2} \times 3.1416 = 183.8,$$

or about 10 inches less than for the former case.

Now apply the same rules to a 20-inch ring. Here the length of stock for the flange out, Fig. 1, is equal to

$$(20 + 1 + \tfrac{1}{2}) \times 3.1416 = 67.5.$$

For the flange in Fig. 2 we have

$$[20 - (1 + \tfrac{1}{2})] \times 3.1416 = 58,$$

or nearly 10 inches less than the other. A considerable difference, of course, is expected.

My proposition as given at the beginning of this letter was to cut the stock to fit the dimensions of the finished ring. Let us see what this amount would be. Fig. 3 is a top view of the ring with the flange out. The actual length of the inner circle of the ring is $60 \times 3.1416 = 188.5$. Likewise the actual length of the outer circumference is $66 \times 3.1416 = 207.35$ inches. Then the stock would be cut as in Fig. 4.

Now we know that there will be some distortion of the stock when forging the ring. The outer edge will stretch and the inner one upset slightly, how much will depend greatly on the diameter of the ring and the kind of treatment given the stock by the forging operator. At best it is a guess until one has made a sample ring, and then the real allowance for this distortion can be measured and relied on. Hence this take-up is a matter of experience, and it is not necessarily the same in different shops. When forging a ring to dimensions not tried heretofore, it is best to measure the stock for the actual dimensions of the finished ring—inside and outside. Then make a liberal allowance for take-up and lap, and then perform the forging operations in some standard way that can be repeated. Note the amount of stock that must be sheared off, and cut the next pieces closer to size than the first piece.

Let us have the experience of the makers of rings and flanges, together with a discussion of the various rules proposed. Have you ever tried cutting the stock as in Fig. 4, and if so, what has been your experience? F. Webster.

Scranton, Pa.

Laying Out a Tube Sheet

The following method of laying out a tube sheet where it is necessary to get the largest number of tubes in a given area on a given pitch, although generally known, may be of interest to readers of The Boiler Maker or to the younger members of the craft.

We will take for example a circular head of an upright boiler, diameter of furnace 60 inches. It is required to get the greatest number of 2½-inch tubes in on a 3¼-inch pitch, all equidistant from each other.

Draw a line through the center of the head *A*, *B*, Fig. 1, and set off the distance from *C* to *D* equal to the number of pitches possible to put on this line, the number in this case being sixteen or seventeen holes. On center *O* and radius *O D* draw the circle *C*, *F*, *D*, *E*. With *C* and *D* as centers, and the same radius as used to strike the circle, draw arcs, cutting the circle at *G*, *H*, *J*, *K*. Connect these six points, extending the lines beyond the circle until they fall away on the flange. We will then have a perfect hexagon. Take the stick on which the tube holes have been laid out for the

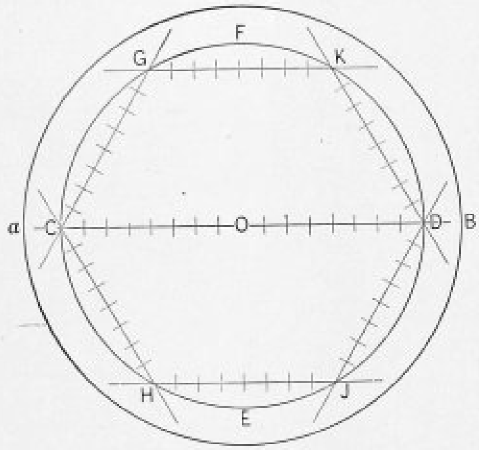


Fig. 1

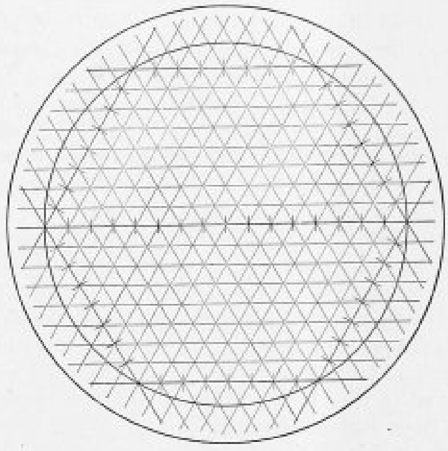


Fig. 2

center line, and lay it on any of the sides of the hexagon, when it will be seen that each side contains an exact number of pitches. Mark off the six sides as shown in Fig. 1, then center with a punch. Now take a good straight edge or chalk line and draw, or strike, lines through the centers parallel with all sides of the hexagon, as shown in Fig. 2; extending the lines as before until they fall away on the heel of the flange, making an accurate and uniform layout, and doing away with the slow process of marking each hole separately with the dividers.

Personal

Gilbert H. Pearsall, secretary of Joseph T. Ryerson & Son, Chicago, Ill., has been made a vice-president of the Jacobs-Shupert U. S. Firebox Company, and will be in charge of the Eastern sales office of that company, with headquarters at 30 Church street, New York. Mr. Pearsall will still retain his position as secretary of Joseph T. Ryerson & Son, with which concern he has been identified since May, 1901. He has been in general charge of the sales of the Ryerson Company since January 1, 1905. Prior to his connection with the Ryerson Company, he held positions in the traffic and transportation departments of several railroad companies. He started his railway experience with the Erie in 1887, located at Owego, N. Y. From 1891 to 1897 he was connected with the Burlington; from 1897 to 1899 with the I. I. & I., and from 1899 to 1901 with the Lackawanna.

CHARLES BREARLEY MOORE has resigned as vice-president of the American Arch Company, and has been elected a vice-president of the Jacobs-Shupert U. S. Firebox Company, in charge of the Western sales department of the company, with offices in the Railway Exchange Building, Chicago, Ill. Mr. Moore was born in McComb, Ill., in 1874 and received his primary education in the public schools, graduating in 1891 from the Kewanee (Illinois) High School. In 1895 he graduated from Lake Forest University and then attended the Northwestern University Law School, from which he graduated in 1898. The Columbia Boiler Company was organized by him in 1900 for the purpose of manufacturing house heating apparatus and boilers. In 1902 he organized the American Locomotive Equipment Company, and was general manager and a director in that company until 1911, when he was elected its president. He assisted in the organization of the American Arch Company in 1910 and was elected vice-presidents and a director of that company, and in 1911 he also organized the Boss Nut Company, of which he is a director. Mr. Moore has invented and developed a number of locomotive devices, the best known of which are his locomotive brick arches.

THEODORE ALBERT, president of the Powell Company, died at his home in Cincinnati, Ohio, Monday, May 27.

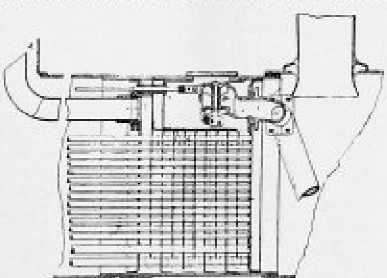
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,013,968. STEAM-BOILER SUPERHEATER. HOWARD D. TAYLOR, OF READING, PA.

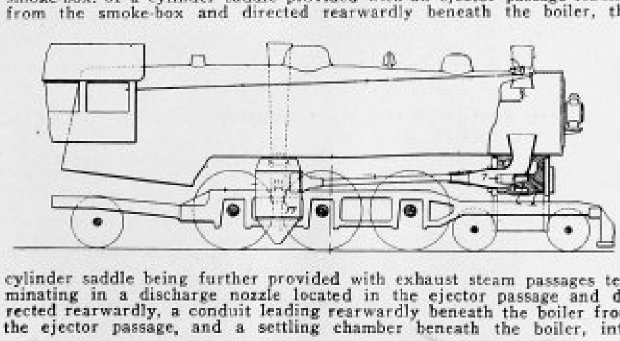
Claim.—A boiler having a partition flue sheet therein forming a cylindrical superheater section rearward of the smoke-box sheet, a longitudinal partition in said section forming a storage chamber therein above the



flues, and a series of vertical baffle plates in said section extending across the flues; the outter edges of said plates being provided with spacing flanges extending between the plates and forming insulating partitions. One claim.

1,014,018. SPARK ARRESTER. HENRY W. MIELKE AND GEORGE M. SERGENT, OF ROCHESTER, N. Y., ASSIGNORS OF ONE-FOURTH TO GEORGE FORT SLOCUM AND ONE-FOURTH TO CHARLES F. MIELKE, OF ROCHESTER, N. Y.

Claim 2.—In a locomotive, the combination, with the boiler and the smoke-box, of a cylinder saddle provided with an ejector passage leading from the smoke-box and directed rearwardly beneath the boiler, the



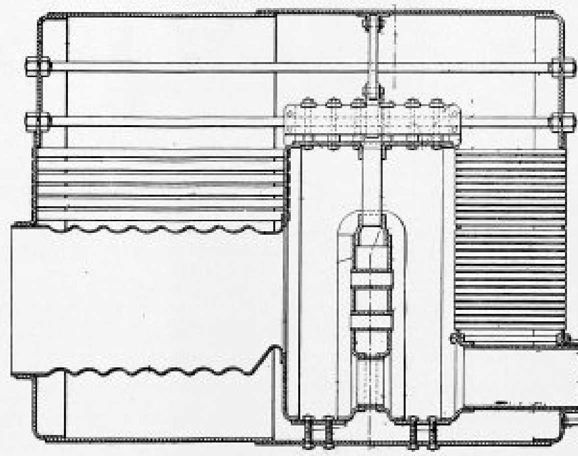
cylinder saddle being further provided with exhaust steam passages terminating in a discharge nozzle located in the ejector passage and directed rearwardly, a conduit leading rearwardly beneath the boiler from the ejector passage, and a settling chamber beneath the boiler, into which said conduit discharges at its rear end, the settling chamber having an outlet to atmosphere. Two claims.

1,015,014. FURNACE. SAMUEL B. GOFF, OF CAMDEN, N. J.

Claim.—A furnace having grate bars, a tightly closed ash pit, means for supplying a blast of air and steam below said grate bars, means for heating said air prior to its entrance to said blast-supplying means, oil vaporizing tubes situated between said grate bars constructed and arranged to deliver the vapors of the oil therefrom to the solid fuel, oil vaporizing tubes in the combustion chamber above the grate bars disposed to cause the vapors of the oil therefrom to intermingle with the gases arising from the solid fuel, and means for supplying liquid fuel to both sets of the vaporizing tubes. One claim.

1,014,238. STEAM-GENERATING BOILER. LUTHER D. LOVEKIN, OF PHILADELPHIA, PA.

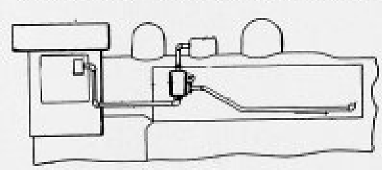
Claim 2.—In a boiler, the combination with the boiler shell, of a combustion chamber located therein and separated from each end of said shell by substantial but unequal distances, furnace chambers and return pipes extending between the combustion chamber and the more remote



end of the boiler shell, and other flues extending from the combustion chamber to the less remote end of the boiler shell, said other flues being arranged to offer a greater average resistance per unit of length to the flow of gases therethrough than thee resistance per unit of length of the said return flues. Four claims.

1,014,919. FEED-WATER HEATER. JARED S. SWEENY AND WILLIAM W. GRINDLE, OF DECATUR, ILL.

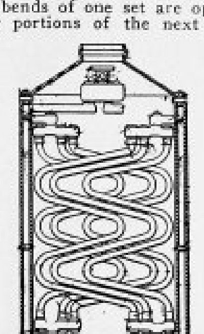
Claim. 2.—A feed-water heater comprising a shell having separate steam and water passages, feed water heating and forcing means communicating with said passages, the shell having a steam inlet port and said steam passage comprising a steam port spaced from said inlet port, an oppositely movable check valve arranged between said ports and



movable in one direction to close the inlet port against back flow from the shell and movable in the opposite direction to close the steam port against forward flow of steam into said steam passage, said valve being normally in open position with respect to both ports, and means to normally maintain said valve in said position. Nine claims.

1,015,936. STEAM-BOILER. ERNST BOELZNER, OF ELMIRA, N. Y.

Claim.—A steam boiler, including zig-zag upflow pipes arranged in sets, and extending transversely of the boiler and nesting one within the other whereby the bends of one set are opposite the spaces between the laterally-projecting portions of the next adjacent set, superposed



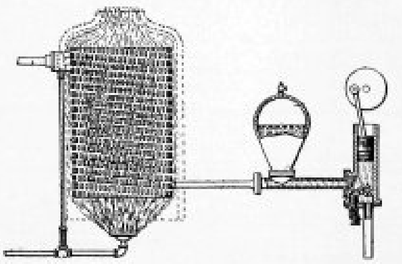
headers at opposite sides of and within the boiler, means for connecting opposite ends of certain of said sets to the superposed headers at one side of the boiler, and means for connecting the opposite ends of the other sets to the heads at the other side of the boiler. One claim.

1,015,527. GRATE. EDGAR C. WILEY, OF LYNCHBURG, VA.

Claim 6.—A grate bar comprising an upper chord; a lower chord; connection between said chords of greater transverse width than said chords and having transverse ducts; and mans comprising inter-engaging projections and recesses for securing accurate register and connection of said ducts, when a plurality of bars is assembled. Eleven claims.

1,015,983. REGULATION AND CONTROL OF STEAM PRODUCTION. ELIHU THOMSON, OF SWAMPSCOTT, MASS., ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

Claim 1.—The combination, of a steam-generator of the flasher type with a regulator for the fuel-supply governed by the temperature of



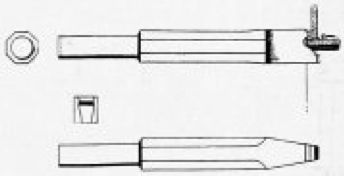
the steam in said generator, and a regulator for the water-supply governed by the pressure of steam in said generator. Six claims.

1,015,746. SMOKE-CONSUMING FURNACE. ROBERT G. SPEER, OF ST. LOUIS, MO., ASSIGNOR TO THE ROBERT G. SPEER CORPORATION, OF ST. LOUIS, MO.

Claim.—In a steam boiler furnace, the combination of a collecting funnel arranged adjacent to the exit end of the smoke flues and adapted to collect the combustible gases therefrom, a trunk extending therefrom, means for effecting a draft through said trunk, a trunk extending from said means and provided with a vertical branch or trunk located adjacent to a side wall of the furnace, a hopper arranged at the upper end of said vertical trunk and adapted to contain a supply of pulverized coal, a jet nozzle arranged beneath said hopper, an inclined partition arranged intermediate of the hopper and jet nozzle, a discharge means connected at one end to the vertical trunk in line with the aforesaid jet nozzle and at the other end with the interior of the fire chamber, and means for introducing a supply of air into the vertical trunk adjacent to the jet nozzle aforesaid. One claim.

1,016,559. FLUE TURNING AND BEADING TOOL. JOHN FRANCIS GERO, OF NEWARK, OHIO.

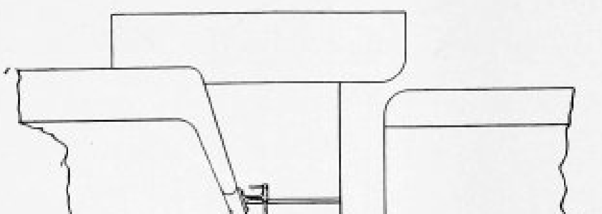
Claim 1.—A tool for turning and beading a flue, comprising a shank portion, a central portion integral with said shank portion, a working end integral with said central portion opposite said shank portion, said wrking portion having opposite converging beveled sides and opposite parallel straight sides at right angles to said beveled sides, one of said straight sides being shorter than the opposite straight side, said



working portion having a flue-engaging end with which said sides connect, said flue-engaging end having a semicircular flue-receiving recess, an outwardly curved flue entering portion connecting with said semicircular recess and the long straight side of said working end, and a short straight portion for said engaging end connecting with the semicircular recess and with the short straight side, said straight portion being at an angle to said short straight side. Three claims.

1,017,170. MECHANICAL STOKER. GEORGE B. RAIT, OF MINNEAPOLIS, MINN.

Claim 1.—In a mechanical stoking device, a reciprocating plunger, a series of forwardly pointing transverse teeth on said plunger adapted to engage and move forward fuel lodged on said teeth, a transverse bar



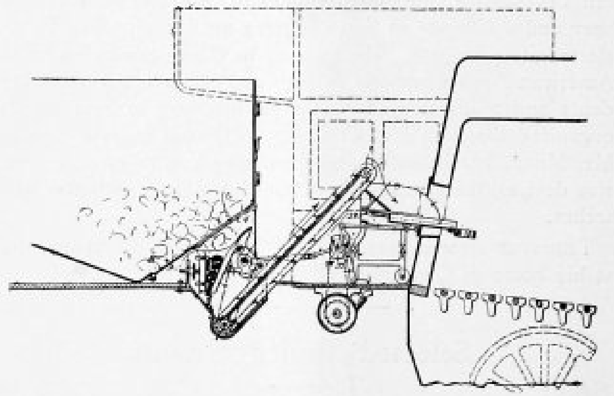
above said teeth having a sharp rearward corner adapted to co-operate with said teeth, and means for operating said plunger, whereby lumps of fuel fed to the stoker and adapted to be crushed between said teeth and bar and to be advanced by the succeeding teeth of said plunger. Five claims.

1,015,460. DEVICE FOR PRODUCING DRAFT IN ENGINES. JAMES TROTTER, OF CHICAGO, ILL., ASSIGNOR OF ONE-HALF TO ALBERT J. HOPKINS, OF AURORA, ILL.

Claim 2.—The combination of a smoke box provided with a stack, flues discharging into the box, a nozzle within the bottom portion of the box, a partition adjacent the ends of the flues and extending from a point above the flues downwardly in an inclined direction and having at its lower end a forwardly extending portion above the upper end of said nozzle, said forwardly extending portion being provided with an aperture co-axially disposed with the nozzle, and a tubular screen secured at one end around the edge of said aperture and having its other end extending around the upper end of the nozzle. Nine claims.

1,017,682. AUTOMATIC STOKER FOR LOCOMOTIVES. ALEXANDER J. McMULLEN, OF MILWAUKEE, WIS.

Claim 1.—In a locomotive having a furnace provided with a feed opening and a detachable coal-tender; the combination of a stoker in communication with the furnace feed opening, a forwardly and downwardly inclined bottom section for the tender, a forwardly and upwardly inclined bottom section in hinge connection with the first named bottom section, the forwardly and upwardly inclined bottom section being provided with a door-controlled feed opening, a coal



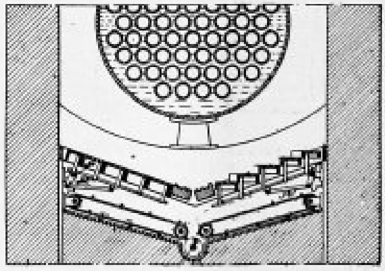
crusher detachably secured to the tender under said upwardly inclined bottom section and in register with its feed opening, an endless coal feeding conveyer apron yieldably connecting the crusher and stoker, a motor carried by the locomotive, an endless belt drive gear connection between the motor and stoker, and a tumbler-rod in gear connection with the stoker and crusher, whereby the same is driven. Two claims.

1,016,994. BLOWER FOR BOILERS. HARRY A. HIGGINS, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY CO., OF DETROIT, MICH.

Claim 1.—A flue blower comprising a steam-supply pipe, a distributing head having a series of separate radial chambers, and a controller for establishing communication between said pipe and chamber successively. Five claims.

1,018,352. GRATE. THADDIOUS V. ELLIOTT, OF NEW YORK, N. Y., ASSIGNOR TO MARIEA ELLIOTT, OF FLATBUSH, N. Y.

Claim 1.—A furnace provided with an inclined grate, having longitudinally extending rocking grate bars, means for imparting a continuous rocking motion to the said grate bars, a longitudinally extending dumping bar at the lower side of the grate and provided with a shaft



adapted to be periodically rocked to turn the bar into a dumping position, the said dumping bar being substantially rectangular in shape and having longitudinal corrugations on its upper face, an arm on the shaft of said dumping bar, and a weight connected by a link with said arm for returning the dumping bar to its closed position. Five claims.

1,018,830. SMOKE-CONSUMING FURNACE. MARTIN L. KRUEGER, OF ST. LOUIS, MO.

Claim.—In combination with a boiler furnace having a fire-box and an ash-pit, air induction pipes leading from the ash-pit and extended along the sides of the fire-box, a heat absorbing and heat retaining ridge projecting into the fire-box beyond the side walls thereof, and traversed by the side extensions of the air induction pipes aforesaid, jet pipes projecting through the ridge aforesaid, terminating in flaring flattened nozzles discharging the mixture of superheated steam and air in vertical sheets intersecting the general line of draft of the combustion products within the fire-box, and supplemental jets projected through the front wall of the fire-box in the general line of draft. One claim.

THE BOILER MAKER

AUGUST, 1912

Oxy-Acetylene Welding and Cutting in Railroad Work

BY C. E. LESTER

There have been few innovations in the mechanical world which have aroused as much interest as the oxy-acetylene method of cutting and welding. In fact, the process is being used on a great variety of work far more extensively than is generally known, and when it comes down to the point of cost of production and survival in the competitive field the man with the oxy-acetylene welding outfit will be in at the finish.

Readers of THE BOILER MAKER may remember the writer's article in a previous issue in which he commented adversely on some features connected with the industry. The first knowledge the writer had of the process was from a demonstration made at the plant where he was employed, and the complete failure of several very simple welds jarred his faith about to the limit. That, however, was a long time ago, and the writer has since learned more about it.

The two prime factors that most tend to injure the process in the public eye are unscrupulous salesmen and poor demonstrators. In all industries there are salesmen who will promise anything to make a sale, and, unfortunately, some of these have undoubtedly got into the oxy-acetylene field, and are promising things for their particular variety of apparatus that as yet have not been accomplished. Misplaced faith in a salesman frequently gets a plant installed, and it is afterwards found that as yet the particular class of work for which it was purchased cannot be done, or at least not commercially. Such methods are to be deplored. Simply by selling a plant to gain a few paltry dollars' commission, or to hold a position jeopardized by poor work in the field, the salesman loses a friend for the process, who, being "stung," does not hesitate to condemn in no mild terms the process in general, and the company who sold him the plant in particular, to everyone who lends an ear to his tale of woe, and does more damage to the industry than can be overcome by a good salesman in a long time.

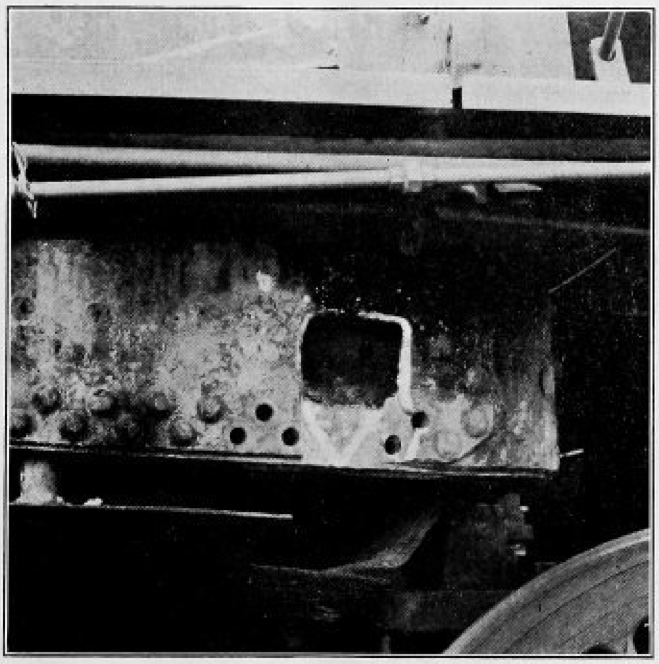


FIG. 1

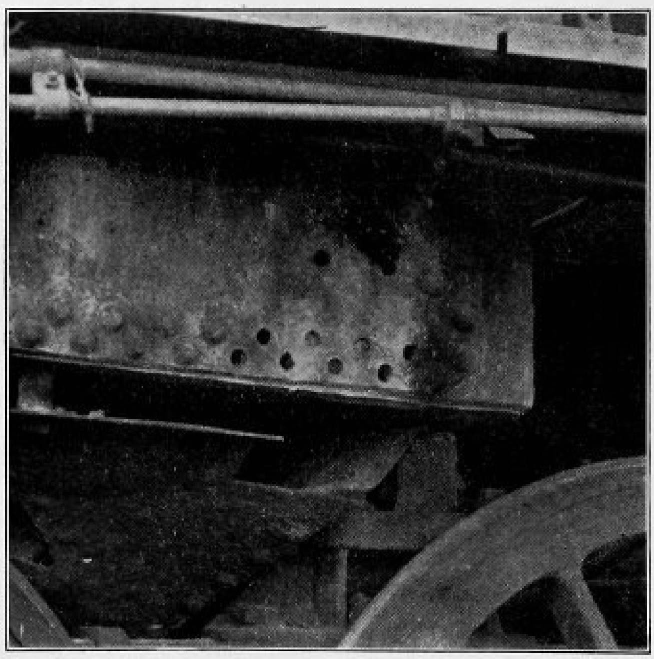


FIG. 2

As a general rule men are prone to condemn anything new which they do not understand in its entirety; and it seems to be quite natural for most of us to condemn rather than to praise. When men are solicited to invest money, if they are true business men and not visionaries, they must be shown the advantages and saving in the investment. To get an oxy-acetylene outfit installed requires probably greater effort than any other staple mechanical appliance, due principally to the fact that the claims for the process seem positively absurd at first, because things can be done that previous to the discovery of the oxy-acetylene process were deemed impossible. It is difficult, I imagine, for one who has never seen it done to believe that cast iron, copper, brass and aluminum can be welded almost as readily as a smith welds a bar of wrought iron. Here is where proper demonstration comes into play. The writer feels that it is a mighty hard matter to convince a man who has seen several simple welds fail that

FIG. 3

the fault is in the operator, and not in the apparatus and the process, but such is nearly always the case.

The writer has had several years' experience in demonstration and repair work, and feels qualified to state that if there are still railroad men (who have seen oxy-acetylene work) in doubt as to the efficiency of the process it is the fault of the selling company in not having a competent demonstrator. Practically every class of repairs that are required to be made to locomotive fire-boxes can be successfully welded with oxy-acetylene by a competent welder, viz., in locomotive boilers, fire cracks of every description, side, door, crown or flue sheets, broken flue bridges, cracked from top flue hole around the flange, patches of all descriptions, wasted places built up, mud-rings welded in position. In locomotive and shop machinery, cracked rods, broken steam chests and cylinders, lubricators, injectors, valve stems, quadrants, driving boxes, gear wheels, bell cranks, air pumps, and other parts innumerable have been successfully welded directly under the writer's supervision within the past year, and with but a very few failures.

Those who possess or contemplate buying an oxy-acetylene plant should bear a few things in mind, viz.: There are right and wrong ways to weld the same as in other lines of work. If you fail the first time—try again. You will get the right way eventually. Try to profit by your mistakes. Do not blame the apparatus for the failures. Get your head working and the apparatus will do its part. Do not condemn the apparatus when you attempt the impossible, with the inevitable result. You can't get a mechanic for 15 cents per hour, neither can you get a competent welder. Apprentices who serve three or four years before qualifying as journeymen, do not expect a welder to become proficient in all classes of welding in two or three weeks. To sum it all up—don't blame the apparatus for what you don't know.

The accompanying photographs show some interesting jobs of welding that were successfully and economically performed by competent welders.

Fig. 1 shows a mud-ring in a consolidation engine that was

FIG. 4

broken through the center of the "V" shown. In order to eliminate overhead welding the patch was cut out of the side sheet and the mud-ring V'ed out from the top with the blow-pipe and afterwards welded together. When the welding of the ring was completed, the patch cut from the side sheet was set back in position and welded fast, as shown in Fig. 2. It was necessary for this engine to be out of service but twelve hours. The actual time of welding was four hours and fifty-four minutes. The total cost of all operations, including stripping parts, cutting, welding, assembling parts, riveting, calking, all gas, rivets, etc., was $19.98. With old methods (all labor and material included), to remove, weld and apply ring, covering all stripping and assembling at piece-work prices, would have cost $117.98, making a net saving of $96 in twelve hours.

Fig. 3 shows a fire-box patch that had given out along the side and bottom. The patch-bolt heads and calking edge were successfully welded over. The writer has, however, had more failures than successes at this particular kind of a job with oxy-acetylene. The job is a very simple and easy one to accomplish with certain types of electric welders.

Figs. 4 and 5 show a job done on a furnace door hole of a consolidation locomotive (Harriman type). It was desired to apply an automatic stoker, and it was found that the fire-hole was too small to permit of successful operation, and a larger hole had to be made. The writer decided to attempt the job with oxy-acetylene instead of the usual method of riveting, or patch bolting collars on the door and back head sheets. The back and door sheets were cut out with the blow-pipe; the collars turned at the flange fire in the usual manner; trimmed to size and beveled with the blow-pipe; set in position and fastened with tack bolts, as shown in Fig. 4. They were then successfully welded, as shown in Fig. 5. The usual objectionable seams were eliminated, and the job completed at a cost somewhat less than by the old methods.

It is hard to figure in dollars and cents the value of an oxy-acetylene machine in a railroad shop. The statement following does this, yet it fails to show the many ways in which work has been expedited by having some small job welded quickly and a broken lathe put in operation quickly, a valve yoke stem on a locomotive cracked or torn out through the key-way welded in half an hour, and five hours' time and labor saved. The locomotive might be the only one available for an important train. Such things as these are hard to figure in terms of cash, but are really the things that count.

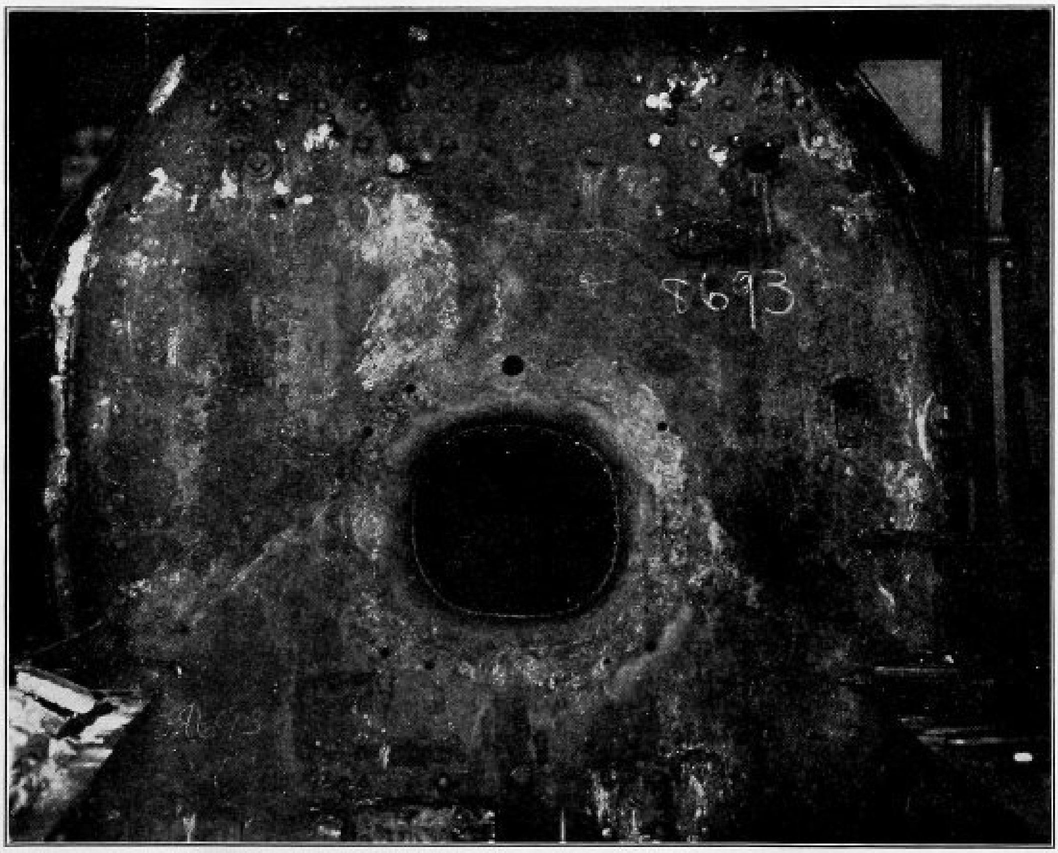


Fig. 5

The following statement is one worked up by the writer to show what was being done with the machine under his supervision, and covers a period of ninety days. Under the heading of "Old Methods" the cost was taken from piece-work schedules, and was really economical. This heading covers what it would have cost to make repairs (labor and material) by the methods usually in vogue in railroad shops. It will be noted in the statement that under the caption "Old Methods" no interest or depreciation is shown. The many different machine tools, and divers methods that would have been employed, would have made the statement a lengthy one. Instead of doing this the cost of material to be used was all figured as being new material, without any depreciation in value. This practically offsets the investment, interest and depreciation on shop machinery and tools.

Statement

Net saving made at ——— railroad shop by the use of the oxy-acetylene cutting and welding apparatus covering a period of ninety days:

Investment, welding machine, appliances, etc.	$1,897.50
Depreciation at 10 percent per annum (second year of service)	42.58
Interest on investment for ninety days at 5 percent	23.65
Labor expended on repairs to apparatus	55.91
Interest on investment for ninety days at 5 percent	23.65
$55.91 (repairs to apparatus)	281.59
Shop expense of 20 percent to cover superintendence	67.50
Material for repairs to apparatus (see note)	208.06
Oxygen, carbide, welding wire flux, etc.	77.46
Storehouse expense to cover freight, handling material, etc., at 3 percent	8.46
Total	$765.21
OLD METHODS	
Labor expended to make repairs to locomotives, shop machinery, etc.	$570.13
Shop expenses, 20 percent	114.02
Material for repairs	618.06
Storehouse expenses	20.43
Total cost by old meahod	$1,322.64
Total cost by old methods	$1,322.64
Total cost by welding outfit	765.21
Net saving	$557.43

Note.—One-half of this charge is really not a legitimate comparative charge, as repairs were made necessary by allowing machine to freeze up.

Modern Locomotive Boilers

The development of the locomotive boiler in recent years has been remarkable. It would seem that its size had been pushed to the maximum limits for both freight and passenger service. Those for Mallet locomotives furnish steam for a tractive effort of 100,000 pounds, and for passenger service they have reached the limits in height and width which roadway and structures will permit, and their capacity is more than 2,200 horsepower. Improvements in the locomotive engine, the use of superheated steam, liquid fuel and very large cylinders have all resulted in decided modifications of the type of boiler in general use a few years ago.

Some of these changes have their effect on the maximum working pressure, and there is a marked tendency toward pressures below 200 pounds. Passenger engines are now designed for boiler pressures of 185 pounds, while recent large freight engines have a working pressure of only 160 pounds per square inch. The heavy cost of boiler maintenance with high pressures and frequent failures of tubes and stay-bolts have had their result in movements favoring the lower pressures. Experience with reduced boiler pressure has been so favorable in this respect that the change is now well established, and the loss in capacity has been made up by various improvements in the design of both engine and boiler.

A study of recent locomotive boilers reveals some variations in practice and some inconsistencies which are difficult to explain. When radically different designs of fire-box are used for the same purpose, it is probable that one form is better than the other, but in the absence of exact experimental data it is difficult to prove it. If each of them furnishes sufficient steam for the engines when performing the service expected they are regarded as satisfactory, though a careful test might show one design more economical in fuel than the other, while its capacity may be less.

We shall consider only one prominent illustration of this, and that is the wavering practice in the use of combustion chambers, with tubes of moderate length in one lot of locomotives and straight tube sheets and very long tubes in another lot, when there is nothing particular in the service which should determine one or the other type of fire-box. The combustion chamber was welcomed as a simple expedient for maintaining a moderate tube length in the very long boilers used where there are numerous coupled drivers. We were told that the front portion of a 20-foot tube has little value as evaporating surface, and the larger area of fire-box heating surface exposed to the direct effect of the hot gases and to the radiant heat of the red-hot fire bed more than made up for the slight loss of 2 or 3 feet of the front tube end. Then, too, very positive claims are made for the advantage of larger fire-box volume which the combustion chamber furnishes for the complete combustion of the hot gases, and we have published the results of tests which show a saving in coal consumption of 10 to 15 percent as a result of such construction.

In the design of the boilers for a Chesapeake & Ohio mountain type passenger locomotive advantage was taken of these claims. These engines are required to haul passenger trains weighing 650 to 700 tons over mountain grades 80 feet per mile at speeds of 20 to 25 miles per hour, and they are the largest and most powerful simple engines in one unit ever built. A boiler of maximum capacity was demanded, and it has a combustion chamber 42 inches long and tubes 19 feet long; with this construction the locomotive has exceeded the required performance. Another locomotive intended for higher speeds—the experimental Pacific type, No. 50,000—has since been built for maximum capacity per unit of weight, and by careful design the weights of machinery have been kept as low as possible, so that the boiler might be enlarged without exceeding conservative wheel loads. Great care was taken in the design of this boiler, and its proportions may be taken as representing the latest and best ideas in regard to fire-box and tube relations. In it we find a straight tube sheet and no combustion chamber, and the tubes are 22 feet long. The performance of this engine exceeds in capacity that of any other Pacific type engine, having developed 1 horsepower for each 121.4 pounds weight of engine. It also shows a greater economy in fuel per indicated horsepower than other locomotives of this type and equal weight.

The railway manager who is ready to order passenger locomotives of maximum capacity and economy will naturally ask why it is that where these considerations were paramount in another case the tubes are 3 feet shorter and a long combustion chamber was used. It may also puzzle the engineer, for we have seen no explanation of these vagaries in boiler design in the most recent practice. It might be said that the Chesapeake & Ohio mountain type locomotives were intended for slower service on heavy mountain grades, and the question of speed has some influence on the design. This explanation fails when we find the largest locomotive boiler ever built—that for the Pennsylvania simple Mallet for slow mountain freight service—has tubes 24 feet 8⅞ inches long and no combustion chamber. This boiler is 104 inches in diameter at the throat sheet, and with the superheater has an equivalent heating surface of 8,000 square feet. The Pennsylvania has made experiments at its locomotive testing plant at Altoona with plain fire-boxes and those with combustion chambers, to determine the relative value of fire-box and tube heating surface; and though the results of these tests have not been made public, we must conclude that the extremely long tubes in the new Mallet locomotive built for that road clearly indicate a preference for a design which excludes the combustion chamber. The boiler performance of this engine will be examined with special interest, for if it meets expectations as to economy and capacity we may conclude that for either passenger or freight service there is no economic limit to the length of locomotive tubes excepting those imposed by the deflection due to their weight and other questions.

We expect that something definite on the general subject here considered will be shown as the result of the extensive and important locomotive boiler tests now being conducted at Coatesville, Pa., under the direction of Dr. W. F. M. Goss. The first series of these tests concerns the determination of the efficiency of fire-boxes of different construction independently of the tubes, and they include measurements of the relative evaporating capacity of a unit area of firebox heating surface as compared with the capacity of a unit area of tube heating surface. With this information at hand the development of locomotive boiler design should proceed consistently and without the variations here noted, which are now so difficult to explain.—*Railway Age Gazette.*

Design, Construction and Inspection of Locomotive Boilers*

Discussion

F. F. Gaines (C. of Ga.): I think this is one of the most valuable reports that we have had submitted in a long time, and I am sure the association is under great obligations to the committee for their very thorough work. As regards the question of a large mud-ring radius, it has been my experience that this is not altogether desirable. We have had some trouble with the large mud-ring radius where we have not had it with the small one, and after having tried it we have gone back to the small radius. In regard to the question of arch tubes, I notice the general practice is to use tubes .18 inch thick. I would like to say that I have obtained better results from the .15 inch than I have from other types. Also concerning the radius of the flange in the back tube sheet, I found a smaller radius there gives better results, and after experimenting with a large radius I have gone back to the small radius. I would also like to endorse the method of using sling stays referred to with the flexible arrangement. I also endorse the plate Z-1, as regards flue setting.

I also would like to call your attention to one other thing that there has not been much said on, in regard to the circulation of water. I find that, contrary to all theory on the subject, wide water legs in the fire-box have not proven, according to all my tests and experiments, as good as the narrow water space, much better results being obtained from the narrow water space. In engines built exactly alike in every respect, except one having a large water space, and the other a small water space, the small water-space engine is a much freer steamer in every way. Of course, it is a little hard on the stay-bolts, but with the use of flexible stay-bolts I think we are fully justified in using the smaller water space.

M. H. Haig (A. T. & S. F.): In the oil-burning engines a radial stay is being used which has a tapered head and no button head. It is screwed into the crown sheet within a short distance of the bottom of the tapered portion, and that end is then riveted over. The taper is 1⅜ inches in 12 inches. The thread is twelve threads per inch (Whitworth standard). The oil-burning service is a little harder on fire-boxes than the coal-burning service, and as this radial stay gives very satisfactory service in oil-burning engines there is every reason to believe it would be equally, if not more, satisfactory in coal-burning locomotives.

It is the practice of one road that I know of to apply six rows of button-head stays at the center of the crown sheet for coal-burning engines, and use the radial stay which I have explained entirely on the oil-burning fire-boxes. I have referred to this radial stay and given these dimensions, as the matter was not included in the report of the committee. With regard to the mud-ring, I also noticed that there was no reference in the report to a greater depth of mud-ring immedately at the corners to provide for calking. One railroad uses what you might call a heavy boss at each corner, which is about ¾ inch thicker than the remainder of the mud-ring.

Reference is also made in the report to the O'Connor type of fire-box door. The road by which I am employed has applied that arrangement on all engines that have been built in the last few years, and it has given very satisfactory service. A request for information as to the performance of this door on the various divisions of the system has resulted in reports that the performance is very favorable. With regard to the large dome to facilitate entrance to the boiler to permit inspection, in my opinion it is a very commendable recommendation. In practice, the boiler inspection rule requires that the throttle must be removed, or that the information be given that an inspection is being made, as far as possible, without removing the throttle. If domes are made large enough to facilitate entering the boiler conveniently, I think that is a point which could be well taken up to advantage. I mention that for the reason that rule has caused some confusion in certain districts with which I have been associated, and some of the boiler inspectors are not just fair as to how they shall make the report, and the Government inspectors are rather strong on that. I think that point could also be looked into with good advantage.

D. P. Kellogg (S. P.): We are using the same style of radial stay that Mr. Haig referred to with good results, except that we use 1½-inch taper. We go a little further and use a thimble on the crown-bar bolt, which goes up against the crown-bar and eliminates the necessity of calking into the crown bolt. Lately we have been applying that without riveting, simply depending on the taper, and we have got good results.

The report speaks of the difficulty experienced from the flue sheet traveling up by reason of the expansion of the flues. In putting in a new fire-box we drop the crown sheet down, and try to make it half the distance we expect it to rise in service, thus dividing the amount of travel, giving it half the amount to start with, and allowing for the other half to bring it to slightly above the straight position.

W. E. Dunham (C. & N. W.): The committee mentions the 18-inch arch tubes. We have been doing some experimenting, using a No. 7 gage and a No. 10 gage arch tube, both iron and steel tubes, but in the bad-water districts of Minnesota and Dakota we find there is not much material difference in the two gages of tubes. The greatest trouble there, especially in South Dakota, is to keep the water in the tube. I do not just understand the reference where the committee makes a reference to the radius of the flange in the back tube sheet, and that two members had increased the radius from ⅞ inch to 2 inches, and then have gone back to the ⅞ inch. It would seem from reading the report that there was an improvement made by going to the 2 inches over the ⅞-inch radius, and I do not quite understand why the members referred to should have returned to the use of the ⅞-inch radius.

In regard to the matter of radial stays with the button head, the committee seems to indicate that the use of hammered heads in the central rows at the top is not general. We considered that the use of the hammered head, especially at the forward end of the box, was entirely a matter of safety and ought to be generally used. In connection with the Federal inspection of the domes and inspection of the stays on the front flue sheet, I see that there is no recommendation brought out on that point, although the report mentions the use of an auxiliary dome or a manhole for the inspection of the boiler. That possibly could be taken care of. I have been thinking of locating an especially large water-washing plug near the front flue sheet and at the top of some of our small boilers so that we can observe these stays.

Mr. Gaines: In reply to Mr. Dunham, I would like to say that the reason for going from the larger radius flue sheet to the smaller radius flue sheet was due to the trouble we had with the larger flue sheet cracking and breaking. Our experience showed that the smaller radius gives very much less trouble in this respect than the larger radius.

J. F. DeVoy (C. M. & St. P.): So far as my personal

* Discussion of report (see The Boiler Maker, July, 1912) presented at the Master Mechanics' convention, Atlantic City, June, 1912, as published in the daily edition of the *Railway Age Gazette*, with whose permission the above is reprinted.

opinion is concerned, the report is about the best I have ever seen. I do not understand exactly now, even after Mr. Gaines has explained it, why he went to the smaller radius sheets, other than transferring the expansion which you naturally get in the large radius back to the location between the rivets and the first sling-stay. It would simply transfer the expansion from one to the other, and it might relieve the cracking in that way. With regard to what another member said relative to oil-burning boilers receiving harder service than coal-burning boilers, that is not our experience in the past year. In our first oil-burning engines we did not protect the seams and the rivets. For the past year we have covered all the seams and all the rivets with brick, so that there is not anything which is any more severe on the fire-box than there was in the coal-burning locomotive, and the only suggestion that occurred to me in reading this report was possibly the fact that later on the committee could designate in some way a standard method of protecting an oil-burning fire-box by the proper location of brick.

There is only one thing in regard to sling-stays in an oil-burning locomotive—it is the button head. On the Chicago, Milwaukee & St. Paul we use a copper washer, only on the coal-burning locomotive, and we still find that in our territory this is as good as any other method. In oil-burning locomotives the button head is used altogether. I would like to see some attention given here to the distance from the belly of the boiler to the lower point of the mud-ring.

W. J. Tollerton (C. R. I. & P.): I would like to call attention to Fig. 5; the scarfing of the seams and riveting the seams. We have been operating the scarfing of riveted seams for about four years, and we know that it does eliminate the flange cracking from rivet holes. By scarfing the seam down one-half the thickness we have been able to run sheets eighteen months without cracking at the rivet holes, and I believe it is a great advantage.

Mr. DeVoy: I want it understood that my remark as to the riveting of seams was directed entirely to oil-burning locomotives, of which we have about 150, and did not in any way refer to a coal-burning boiler.

S. L. Bean (A. C. L.): Concerning oil-burning engines, I might say that we used the submerged seams with the present door sheet. As to the flue sheet, we tried the submerged for a short time, and it worked fine; but we have to work the flues so hard that a vertical expansion takes place, and as it goes up you encounter a greater defect. Your crown sheet cracks right across immediately back of the flue sheet. With the door sheet it works fine where there is no working of flues to disturb it and it helps it wonderfully. One of the gentlemen spoke with reference to putting on some brick. That helps it, but it is desirable to get away from it, and we only use that to prolong weak boxes. We find that the button-head stays will peel off in a year or so. We invented this taper head and slightly riveted it over, and now they last practically the life of the box without renewal. Occasionally we do have to renew some of them. We have extended the oil-burning fire-box period of service from about eighteen months to a record as high as seven years in heavy consolidation locomotives used in mountain service and in a bad-water district. And I am free to recommend that taper radial stay. It will surely hold under all conditions, and I don't think it costs any more to apply than the button head. I think Mr. Kellogg will bear with me on that.

With reference to the doing away with the large flange in the flue sheet or bend, we find with a short bend that the metal was somewhat disturbed and a pitting took place much quicker. We also found that with the thimbles under these crown-bars the forward ends pit immediately under the thimbles and destroyed the life of the fire-box. We took them out, and now find we prolong our boxes a great deal by patching. There is where the seam brick comes in pretty well. You can patch the top flange of a flue sheet with a submerged patch, and by using a light seam brick we sometimes get over a year's increased service at a slight expense.

E. W. Pratt (C. & N. W.): I would like to ask Mr. Bean if they use a thimble under the crown-bars on their oil-burning locomotives?

Mr. Bean: Three in each row. We do that in order to keep away from that burning.

J. A. Pilcher (N. & W.): I wish to say in connection with the matter of construction that we have been making some experiments with very wide water space, as much as 7 inches, and it has been very favorable. We have been using it now for several years, and applied it to something like 250 locomotives, and I understand from the reports that we have been getting that it has decreased the stay-bolt renewal as well as increasing the circulation, and keeping the boilers clean around the mud-ring. Of course, like most boilers on large locomotives, we have had some trouble in getting all of the depth to the front leg of the fire-box that we would like. It seems to me the increase of the water space has been entirely favorable.

Mr. Gaines: I would like to ask some of the members who have had experience with oil-burning locomotives about how soon we should look for trouble when a coal-burning engine has been changed to oil burning.

Mr. Kellogg: I will answer Mr. Gaines, that he will have no trouble until he gets out the button head that Mr. DeVoy said he was using already. I cannot use it. I would say that this method of reducing the flange is also very necessary. We want nothing projecting inside of an oil-burning fire-box than can possibly be prevented.

Mr. DeVoy: I absolutely agree with the last speaker, and perhaps he was mistaken. You cannot have anything projecting at all. We countersink all the rivets and the flange stay, as referred to here, with the taper, and a slight button head is what we use, getting away from as much projection as possible everywhere; so that in order not to confuse between our standard practice of the Chicago, Milwaukee & St. Paul, I call the other the button head. So I thoroughly agree with you in that. There is but one way to do any transferring from a coal-burning to an oil-burning fire-box—put on a piece of brick just as soon as possible. You can patch it just as easy as you can a coal-burning boiler. And apply the brick to it and you won't have any trouble at all. It will repay you for many a failure.

W. J. Tollerton (C. R. I. & P.): I may say for Mr. Gaines' information, that you will have very little trouble with your sheets cracking behind your brick. The cracking will occur above the brick, and you will have much better satisfaction if you slip your brick out slightly outward; even on a vertical sheet it has a tendency to keep the brick in place. A little broken glass thrown on top of the brick will help you very much in your performance.

A. G. Trumbull (Erie): Our practices are very well covered by the report of the committee. However, I should say in regard to Fig. 10 that many of these stays have been submitted by railways that have very good water conditions.

The second one, for instance, could hardly have been better designed as a mud-catcher if that had been the aim. We have used with considerable success the type of throat sheet stay shown on Plate T-1 of the supplemental report; our idea being that it was rather incongruous to attempt to resist the influence of expansion by the use of a collared stay, and, as far as my observation goes, we have not had a single case of cracked flue sheet where the crack is of any length since we commenced to use a particular type of stay. I have been also interested in the standard method of setting flues as illustrated in Fig. 15, and it seems to me we might very well dispense with the flue-flaring tool and utilize, instead, the sectional expander, which, as illustrated here, will answer every purpose in setting the flue, and also in turning the end of the flue over, so that it can be properly beaded. I also think we can very well use the sectional expander instead of the ferrule expander here illustrated, thereby reducing the number of tools, and consequently the maintenance, and possibly enable us to follow up the practices in engine houses much better than we could with the number of tools that are here illustrated.

Mr. Pratt: As a member of this committee, I am of the impression that there was no report made by any of the members concerning the service of the Jacob Shupert fire-box or its design, and that is the way I can account for its omission in this report. This report is a résumé of the reports of the different railways that took the pains to give the committee the information they desired. I think it would well pay the designers of boilers to consider the suggestion of the committee with regard to length of flues, wherein it is rather modestly stated that the lengths of over 16 feet be given careful consideration, and when we obtain Prof. Goss' report of his evaporation efficiencies, as between the fire-box and the flues, I believe that that will even be more strongly brought to our notice. It is apparent from his preliminary report that the fire-box evaporation is from 50 to 54 percent of the entire boiler evaporation. Therefore, it may not be that there is very much obtained by the few feet additional length on the front of the flue, while there would be a great deal gained apparently by an increase in the fire-box by using the combustion chamber. I may not be correct, but it is my impression that more of the railways are doing away with the two holes than are going to the double fire-doors.

Relative to the thickness of arch tubes, I believe the water conditions have more to do with the results obtained by the different members, one getting the best results from a heavy arch tube, and another with a light arch tube. On the Chicago & Northwestern road, where we have some pretty poor water and some divisions with treated water and pretty good water, we have found that in the latter case they recommended the light arch tubes, while in the poor water district they preferred the heavy arch tubes, and got better mileage out of it. We experimented with several locomotives, making a gage or tram to indicate the upward movement of the top of the flange of the back flue sheet, due to repeated expansion, and in a locomotive with about 400 flues, I don't remember the diameter of the shell, we found that the top flanges of the flue sheet moved upward from 5/8 inch to 3/4 inch during a year, with expansions approximately once every month. We tried the O'Connor fire-door flanges out very thoroughly before we adopted it as standard on the Northwestern, running engines with and without it in the same districts, especially poor water districts, and I found it to be quite an advantage. We have over 1,200 locomotives just equipped. In fact, we have nearly as many locomotives equipped with the O'Connor flange on the Northwestern roads as on all the other roads in the country combined. But the reports in the extremely bad-water districts in the Southwest and the extremely good water districts, where the trouble with the doors and door sheets was due to expansion and contraction, appear to be about the same. In applying this door to a new design where the stay-bolts are laid out as we would suggest, the nearest bolt on the door sheet side is from 7¼ inches to 8 inches from the edge of the door hole, which gives a much better expansion and contraction. We are new in the oil-burning business; we have less than fifty locomotives at present equipped for burning oil; but we find that with the front-end burners, as they are being used by most of the oil-burning roads, the flame strikes the door sheet and gives more trouble than with the coal-burning engines. With the expansion and contraction that are permitted in these door sheets, by means of this flange the door lasts very much better than the ordinary type of door. In fact, we find that the large proportion of our engines that are in the boiler shop are receiving new flue sheets and side sheets, and the door sheets require no attention whatever, either about the flange or about any part of the door sheet.

F. J. Harrison (B. R. & P.): I would like to ask the gentleman who has just spoken if he found any accumulation of mud about this door sheet?

Mr. Pratt: We did not. There appears to be a much better circulation around the door on account of the greatly enlarged water space, and more particularly because the stay-bolts are far away from the door; but I believe it is proper to put a wash-out plug above any door. We know there is more or less scale that falls down there, and it is quite a distance from the wash-out plugs which go above the crown sheet, and it would be found quite an advantage to have a wash-out hole above any door to wash it out.

Angus Sinclair: Taking the substance of all the reports on boiler construction that have been presented to this association, I think that this is the best one I have ever examined, and I think it is very creditable to the committee that they have made a synopsis of the whole tendency of progress in boiler construction, and everything that they have recommended seems to be in the right direction.

D. P. Kellogg (S. P.): To prevent accidents due to low water in the boiler we have endeavored to perfect an apparatus which has proven satisfactory so far. It is operated by a difference in temperature, which is secured by entrapped water in a cup, and partially cooled to about 50 degrees lower in temperature than the water in the boiler. When the water falls to any prescribed limit, the man in charge of the locomotive sees the danger line, or steam enters and expands the mercury in the device which opens a steam valve, and causes an audible alarm or controls the fire. In the case of an oil-burning locomotive, it shuts off the fuel supply, and in the case of a coal-burning locomotive it sprays the fire with a jet of water. There are about forty of these devices in use on the Southern Pacific. At the present time they have proved quite satisfactory, and it is our expectation we will extend the application of them to a very large extent.

J. Snowden Bell: As a member of the committee, in considering the replies that were received from the roads to our circular of inquiry, I was surprised and disappointed at the comparatively little amount of information which we received on the subject of combustion chambers. Now, in view of the admitted superior evaporative efficiency of fire-boxes and heating surfaces, and the ability to attain it by the use of the combustion chamber, it has always seemed to me very desirable that they should be adopted unless there is some good reason to the contrary.

M. H. Haig (A. T. & S. F.): Most of the discussion has centered on the construction of the boiler. At the same time there has been more or less discussion during the entire convention with regard to economies. There is some reference in the report to the method of delivering feed water, and I will refer to one arrangement by which water is delivered to a perforated pipe connected to each boiler check—the water coming out of these various perforations in the pipe falls on a plate above the tubes, and the claim is that cold water does not settle so readily at the back of the tubes. I would like to ask some of the members for an expression of experience with regard to that method of delivering feed water. One of these devices was placed on an engine on a Western road six or eight months ago, and the only report given so far was from one of the road foremen engineers who has been following this engine. His claim is that the engine uses less fuel and less water, and at the same time he states there is a greater tendency for water to be lifted to the throttle. That latter feature, however, is a shortcoming that no doubt can be overcome.

C. E. Chambers (C. of N. J.): Mr. Bell raised the question of absence of information concerning combustion chambers. I presume all anthracite roads, nearly all, at any rate, at one time all used combustion chambers on their engines. There is no doubt at all as to the efficiency of such chambers in aiding combustion, and the aid to the steaming of the engine which follows when the combustion chamber is in good shape, thoroughly clean and the flues clean. However, the use of the combustion chamber means the drawing of the fire at least once a week, and the cleaning out of ashes accumulated behind the brick wall, and the boring out of several of the bottom rows of flues which naturally block up. There is another condition against it; it reduces the number of flues in the boiler, and we also naturally have a small circulation space between the bottom of the combustion chamber and the boiler shell. This requires close watching, if the water is at all bad, to keep it from blocking up. Eliminating these arguments against the combustion chamber, there is no question at all about the good you get from it, so that, after all, it is simply a matter of the conditions that will govern whether you will or will not have a combustion chamber.

A few years ago we changed from the combustion chamber in several types of locomotives, when we were making renewals of the fire-box, to the D-flue sheet type. We also had a number of boilers built with straight flue sheets, and as the boilers required new tubes, flue sheets or throat sheets, we applied the D sheet, because of the short life we got from the straight flue sheet and the shallow fire-box. I find an increase in the life of the D sheet of as much as 40 percent.

I think Mr. Trumbull made some mention as to the number of tools we have designated for the purpose of applying the various sheets to the boiler. We, of course, attempted to indicate what we considered was good practice. My experience with the average engine house is that if you let the machinist have his own way, his kit of tools will consist of a pinch bar, a hammer and a chisel, and we have designated here what we think is good practice, and have defined the use of suitable tools for the different purposes provided.

One of the members spoke of going to the extent of 7 inches in the water space in the legs of boilers. I do not know how long he has used that space, or how closely he has watched the operation of it, but it seems to me you get a very sluggish boiler with 7-inch water space, and while it may not plug up, I cannot agree to the efficiency of such a spacing. My idea is, and always has been, to use as little space as possible, and keep it clean if you want to get a good and efficient boiler. As to the scarfing of seams in fire-box sheets, that has been tested out very thoroughly on the Central of New Jersey, and in our opinion there is no question about the good results obtained.

F. F. Gaines (C. of Ga.): In reply to Mr. Bell would say that my experience originally with the combustion chamber is very similar to that of Mr. Chambers. At one time I was in the anthracite district, and was pretty well acquainted with the combustion chamber as it then existed. I have been a little hesitant about saying much about the thing, but I would like to refer to Fig. 2 of the report and answer some of the objections Mr. Chambers has made to the combustion chamber and show that these can be overcome. For instance, you can completely remove at any time any sediment, sparks, etc., deposited in the combustion chamber. You also get rid of the water legs, but do not cut down the number of flues. I would further say that there is an absolute coal economy of about 15 percent, which was determined on very carefully and thoroughly conducted tests. I would also say that in the matter of flue economy it is very much more than that. Engines in the district where the first engine was equipped with this combustion chamber, ordinarily make about 25,000 to 30,000 miles, and the first engine so equipped has now made over 110,000 miles, and during the time that it has been making this mileage we have not had a request from the engineer to blow the flues. The engine has been in the shop twice for tire turning, and the flues were examined and probably blown out, but the flues have not been blown out in the engine house, as far as I have been able to ascertain.

It also does another thing—with the soft-coal engine it would not be so noticeable as with an anthracite engine, but it eliminates to a large extent sparks and smoke. An engine with this device properly applied will not emit any black smoke, and but a minimum of brown smoke, and the sparks are noticeably absent. The amount of cinders found in the front end is about 25 percent of what you find in the ordinary engine, although we are using in the front end what you would style a self-cleaning front end.

We also found in our short experience not enough to pass on the matter definitely, as we have only had the superheater engines in connection with the combustion chambers for six weeks, and have not found it necessary to blow out the superheater flues, that there is very little trouble with the flues. We have yet to find any indication of these flues stopping up or giving trouble, as they have done in many cases when soft coal is used. In regard to the question of the maintenance, the fact that the engine has made this large mileage as against the ordinary mileage answers that point thoroughly. We also got rid of another point Mr. Chambers referred to; that is the multiplicity of seams due to the ordinary type of combustion chamber; you have no more seams than with the rest of the fire-box; you simply have a longer fire-box, which gives a greater fire-box heating surface.

D. H. Deeter (P. & R.): When we first started in designing the wide fire-box we had the old sloping baffle sheet at the top. After having seventy-five of these locomotives, we found with the amount of service that was required of the engines they would not carry the water properly. Our combustion chambers were 22 inches in length at that time. The depth from the bottom of the combustion chamber to the bottom of the barrel at the throat sheet was about 7 inches. We had tried various sizes of flanges at the throat sheet from 1½ inches up to 3 inches, but mud would collect at that point. We had quite a little trouble with the bottom of the combustion chamber becoming blistered and burning out, and in two or three years becoming detached. By removing about eight of the flues every six months or a year, in addition to two or three of the bars, that trouble was all eliminated. This is a small matter compared with the amount of saving of fuel.

After trying these engines for about fifteen years we put on the straight wrapper sheets, and found that we could carry our water more easily and steadily over the road, also obtaining better circulation. Now, in my estimation, if we could lower the depth of the sheet 3 or 4 inches more than it is it would be an advantage, as Mr. Gaines says, but from the fact of the construction of the wide fire-box it is really impossible to go down any further than we are now, because you cannot get rid of the ashes so readily. They seem to clog up along the side.

Regarding the trouble with the bottom flues in these combustion chambers we are losing sight of the fact that it is not altogether on account of the construction. Years ago it was very seldom that we would remove the flues. A good deal of the trouble can be laid to the fireman. In previous days he was more careful, and we should teach the fireman to properly fire his engine. Furthermore, we have found that the fireman is more or less anxious to fire with both fire doors open at one time, which is very hard on the fire-box. We have cases where we do not clean out our combustion chambers on our fast freight engines once in two weeks, but on our high-speed locomotives we are really compelled, as Mr. Chambers says, to clean out the chambers twice a week.

We find that a 2-inch flue is the most serviceable flue that we can have for a wide fire-box locomotive with a combustion chamber. We have tried all sizes of flues, from 1¼ inches to 2½ inches. We changed from the combustion chamber about ten years ago on our D-5 engines to what we term a combination flue sheet. In my experience in handling these engines I found our principal difficulty was to keep these combination sheets stayed properly at the bottom or close to the firing line. The life of these combination sheets ranges from about two and one-half years to four years. We have discarded quite a few of them and gone back to the combustion chamber, and I find the combustion chamber is economical as to fuel, and the life of the fire-box is about eight years as compared to four years in the case of the straight sheet.

Mr. Chambers: For fear that the members may think from the remarks I made that we have discontinued entirely the combustion chamber, I wish to say that at the present time we are building engines both with the combustion chamber and without, largely governed by the service they are going into.

F. T. Slayton (Virginian): I should like to ask if any member present has had experience with the welding of flues to the flue sheet? Several speakers have referred to the growing of the flue sheets, that is, the expanding of the flue sheet in an upward direction, which must be due to rapid working of the flues, with Prosser and roller tools, which not only has a tendency to cause cracking of sheets, but must necessarily take the pressure off the first stay-bolts next to the seams, thus transferring the load to the next row of stays, and so on, thus doing away really with the use of the first row or rows of stays. It seems to me that if we could avoid this excessive working of flues we would overcome that trouble.

I understand some of our members have had experience with welding in flues for a year or more. I recently made a test of this kind which has proven very favorable thus far, but I do not know what I am going to run up against later. About three and one-half months ago I took an engine, which was in service, where it was compelled to take brackish water entirely from one tank, and had extremely hard service on account of pushing cars over a hump and then drifting into a yard, where it was worked to its full capacity for probably thirty minutes, then drifting around for an hour. The engine got into such shape that it was necessary to "kill" it practically every day to work the flues. The engine was supposed to work day and night. We welded in the flues, and since that time we have had no trouble whatever. This was an engine in which the flues were all set in the regular way, and the welding-in simply consisted in sealing the joint between the bead and the flue sheet. By making some experiments with a section of flue sheet with the same welding process, we found we could get a better job by simply letting the tube project through the sheet, the same as for rolling and beading, and then fill in between the end of the tube and the flue sheet at an angle of about 45 degrees. It made a neater job. We also tried belling out the end of the flue and welding in a similar way, but found there was a tendency to burn off the edges of the end of the tube, and that we could get a better job by allowing the tube to extend through straight. This engine is now in the shop for general overhauling, but we are not removing the flues, as they did not give us any trouble, and we wish to continue the experiment.

I next welded in the flues of a Mikado engine having a tractive effort of 55,900 pounds, hauling 100-car trains of 7,600 tons in regular service, and welded the flues as well as the fire-box seams of this engine. This engine remained in that service until about a month ago, when it was put in lighter service on the mountain, and the engine comes to the terminals only for wash-outs. This engine has given no trouble from leaks in the fire-box, although previous to the welding of the tubes we had had considerable trouble from leaky tubes. In the case of the road engine there were also about forty fire cracks in flanges or sheets which were welded successfully.

Thomas Roope (C. B. & Q.): We have only one class of power in which we have welded our flues, and that is the Mallet, equipped with double boilers. When we discontinued using the hot boiler and feed-water heater and obtained steam from both boilers, we found it necessary to weld the top flues in the front boilers. We were not able to keep them tight in any other way. The engine has been running now for about one year, and up to the present time has been successful.

C. A. Seley (C. R. I. & P.): I do not believe that this committee should be criticised at all for matters omitted from the report. They have given a compendium of information of great practical value of the practice of the railroads in regard to the design and use of boilers, as contained in the responses to the committee's circular of inquiry, which was very voluminous, as members will remember, no doubt, and the committee has framed up a very useful and valuable report. I think we are exceptionally fortunate in having this report for our proceedings and as a guide in our practice.

Prof. W. F. M. Goss: I have prepared no discussion of this paper, although it is one which interests me very much. I am impressed both with the report of the committee and with the discussion that has been based upon it, with the fact that in very many matters of detail entering into the construction of a steam boiler much depends upon related details, and it seems to me that the conclusions of the various members of the association responding to the requests of the committee for information need to be very carefully analyzed before they are in all cases safe as guides to practice. I think the one statement which has been brought out in this discussion which interested me most is that of Mr. Gaines, and some others, which seems to advocate a narrowing of the water legs of the boiler. I had rather the feeling that progress in the design of locomotive boilers during the last fifteen or twenty years had been expressed as much by a tendency to give greater width to the water legs as by any other tendency, and so I must confess to a great deal of surprise to find there are some who feel that that movement has been carried too far.

Of course, our problems in locomotive design and maintenance change from year to year as practice leads us into new fields. If we look back into the development of the last twenty-five years we shall have ample evidence of that fact. When our boilers were small most of the railways were using the crown-bar form of construction, and to my mind that form of construction is necessarily associated with the small boiler of a good many years ago. There is no chance, as it seems to me, to enter into a discussion of the crown-bar type as applied to our modern large boilers. We continued in the use of the crown-bar until the forces to be sustained by the crown-bar became too great for satisfactory treatment through that form of design, and then we went to another form, the radial stay, and between, perhaps, the crown-bar and the full fruition of the radial stay, came the Belpaire boiler, and I take it that the railways for many years past, the past decade anyway, have been devoting themselves pretty largely to the perfection of the radial-stay type of boiler, and the result is a highly perfected design, in the perfection of details of which we are pretty largely engaged at the present time.

But now the radial-stay boiler has grown to dimensions undreamed of over ten years ago in general locomotive practice, and there is no doubt in my mind but the radial-stay boiler is going to continue to grow, and that fire-boxes will, in one form or another, continue to increase in size, and what are the problems of the future with reference to such a possible development? That is the large question to look forward to in considering the tendencies in locomotive boiler design, and keeping that in mind it seems to me that some of the propositions which are now being put forth, especially that which has been referred to as represented by the Jacobs-Shupert type of boiler, becomes in the light of possibility of future practice, and of the increasing demands of every-day practice, a matter of very great significance and interest.

G. H. Baker: I wish that the committee could be continued, or that another committee should take up a branch of the subject which has not been dwelt on in the present report. After a boiler is constructed it must be operated. During the twenty years I have been a member of this association there has never been a committee, I believe, that considered the subject of the management of locomotive boilers and their operation, although two of the speakers here this morning have brought in the importance of the human element—the engineman and the fireman.

Rapid Drilling of $1\frac{1}{16}$-Inch Holes in 1-Inch Plate

For the final riveting of the enormous lock gates at the Panama Canal, the McClintic-Marshall Construction Company, of Pittsburg, has installed sixteen special electrically-operated machines for drilling and reaming rivet holes. Each of these machines weighs about 6 tons, and it is claimed is capable of doing the work of five of the ordinary type reamers.

The machines are designed to run on a standard gage track, and are mounted on broad, adjustable scaffolds, which are suspended from brackets by chains from the top of the gate, as shown in Fig. 1.

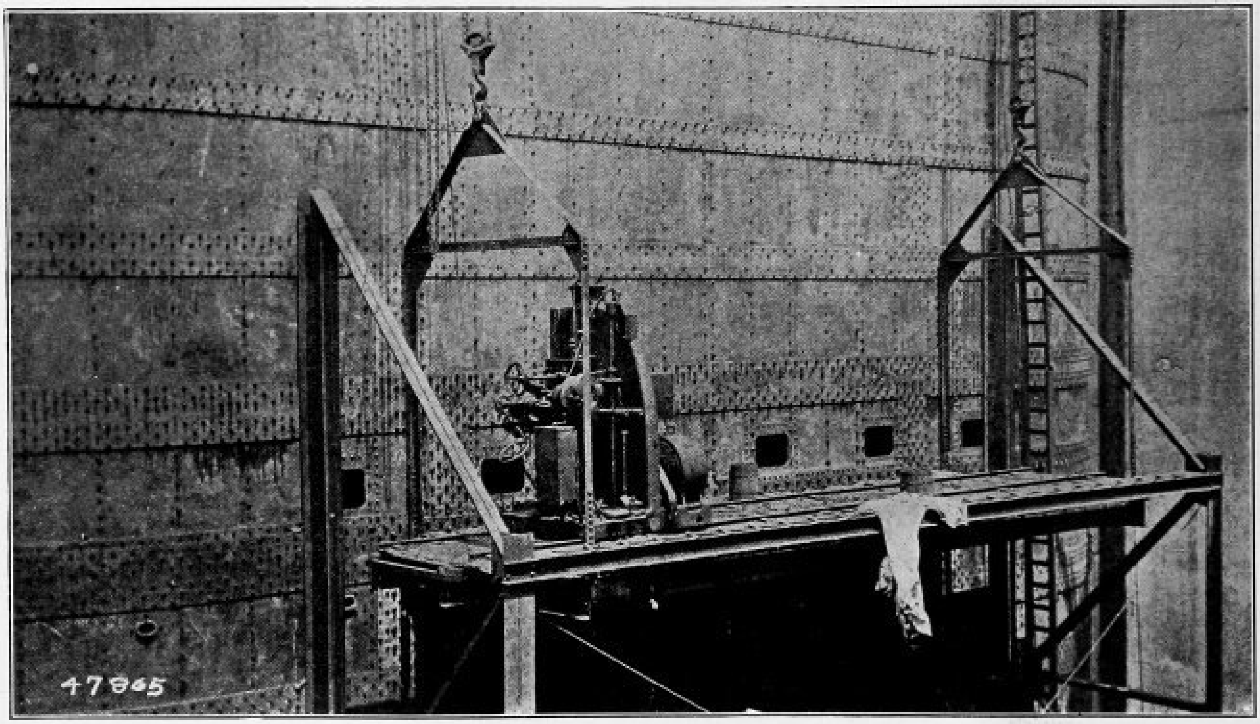


FIG. 1

The inclined hand-wheel shown in Fig. 3 operates through a train of gears and moves the machine along the track. The tool can readily be moved, as roller bearings are used. It will be noticed from Fig. 3 that the entire controlling mechanism is placed within easy reach of the operator. The horizontal hand-wheel shown in Fig. 3 actuates suitable reduction gearing and a screw which raises or lowers the spindles, while the quick return motion through the spindles is actuated by means of the spider hand-wheel or by any of the four levers shown in Fig. 3. These levers automatically engage the quick-return mechanism and enable the spindles to be run in and out.

Each machine is provided with four changes of power feed, which are instantly available through the quick-change gear mechanism. The length of the power feed is 16 inches, and the machine is so arranged that either one or both of the spindles can be fed independently.

The clutch lever for placing either spindle in operation can be seen in Fig. 3, immediately above the number 15 on the head of the machine, while the feed lever is seen just above the clutch lever through the hand-wheel. This hand-wheel is used for raising and lowering the head, which in turn is accurately counterbalanced, so that this raising and lowering is done with the least possible effort. A shackle at the top of the machine, as shown in Fig. 2, serves to attach the crane hook for raising and lowering. Westinghouse direct-current, adjustable speed, shunt-wound motors, rated at 10 horsepower, 220 volts, are used, and the method of the driving is shown in Fig. 2.

These machines were placed in operation in February, 1912, on the main gates of the upper lock at Gatun, and it is intended to use them on all of the gates in the three sets of locks. They were designed and built by the Foote-Burt Company, of Cleveland, Ohio, especially for use on the canal. The distinguishing features are their great capacity; a total of nine speeds, varying from very slow for heavy drilling to very high for lighter reaming, and fixed spindles arranged to suit the uniform spacing of rivet holes in the lock gates.

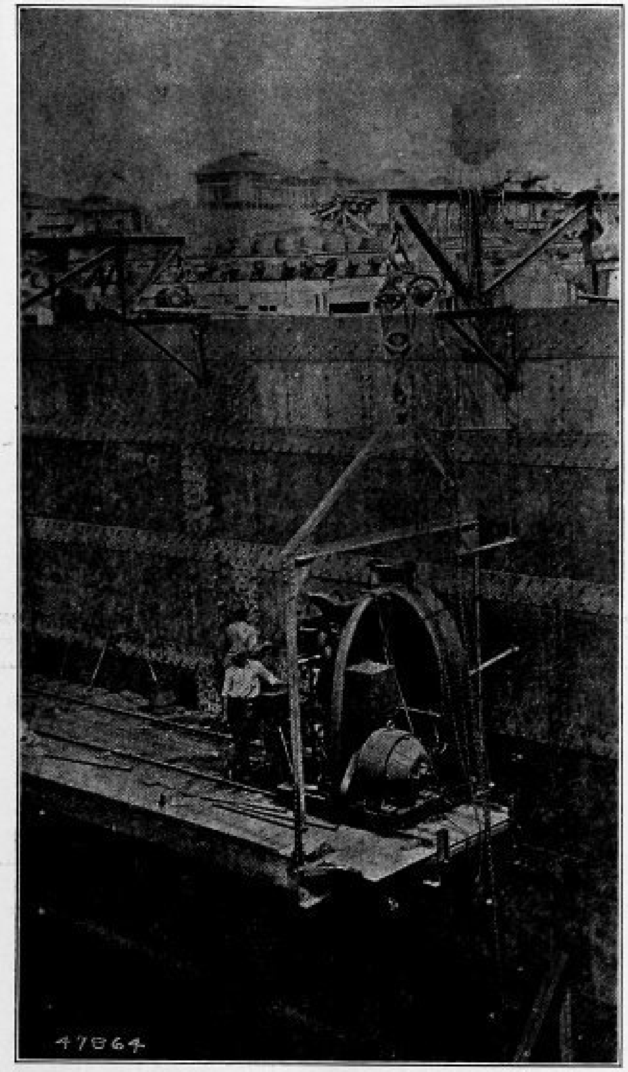


FIG. 2

On tests made at Gatun, one of the machines drilled 1 1/16-inch holes through 1-inch plates in four seconds, or at a rate of 15 inches per minute.

Operation of the Boiler Inspection Service

A highly interesting discussion on the operation of the Federal locomotive boiler inspection service was participated in at the May meeting of the New England Railroad Club. One member expressed his estimate of its value to the mechanical departments of our railways by offering to supplement the preamble of the act creating that service, which reads: "An act to promote the safety of employees and travelers on the railroads by compelling common carriers engaged in inter-State commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto," by adding, "and incidentally to assure the tranquillity and peace of mind of the average master mechanic and engine-house foreman who have to do with the care and maintenance of same." Whatever the attitude of the operating department, there is little doubt that this indorsement, possibly in a milder form, is almost universally agreeable not only to the average master mechanic and engine-house foreman, but also to the line and staff throughout the mechanical department. Any competent and self-respecting mechanical officer naturally strives for the identical results that are sought by the boiler inspection service, but heretofore it has happened these officers have not been permitted to use their best judgment in the relegation of unsafe and antiquated boilers and boiler parts because of the unsympathetic attitude of some higher authority. Likewise the honest effort of some far-seeing though isolated master mechanic, even when not interfered with by the repressive attitude of his superiors in the operating department, has been lost through the lack of co-operation

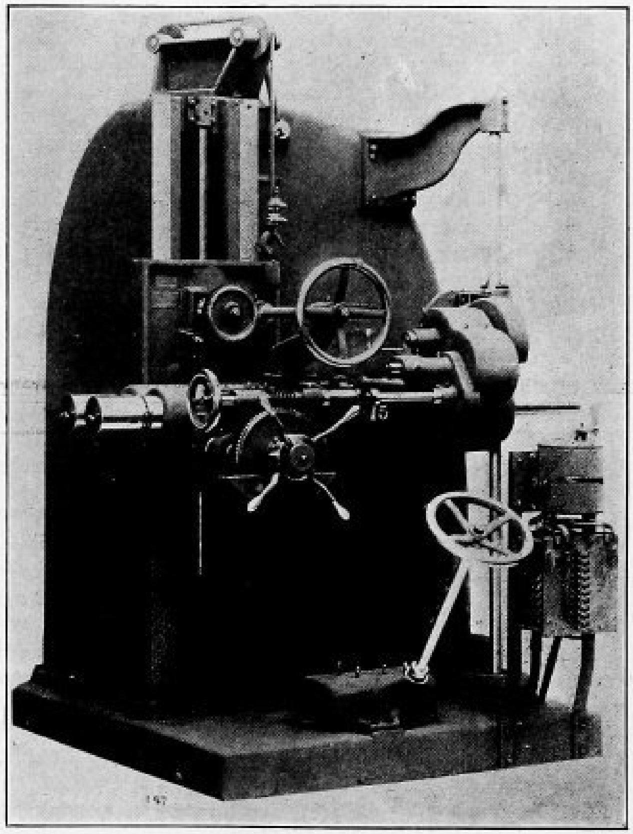


FIG. 3

on the part of his fellows, or even through lack of standard methods and requirements among those having similar responsibilities, and who are equally zealous in maintaining a high standard of safety. The requirements of the boiler inspection act serve to remove the possibility of restraint, such as might come from other departments of the railroad's organization during times of exceptionally heavy business or of unusual economy, and, being universally applied, offer encouragement from the fact that individual effort is everywhere co-ordinated and is productive of results.

As a part of the same discussion mention was made of the great drawback to boiler inspection under governmental supervision in States where State inspection systems are also in vogue. The excessive amount of clerical work necessary to satisfy both the Federal and State authorities, and where, as in the case of Massachusetts and New York, inter-State traffic exists between States, both of which assume supervision over this work and each in its individual way, the clerical work required not only becomes absurd but well nigh intolerable. In Massachusetts, for example, to satisfy each of the two States, the National Government and to preserve the roads' own records, the operation of washing out a boiler requires the filling out of five forms, a hydrostatic test requires fourteen forms, and the quarterly inspection results in the making out of twelve forms, a total of thirty-one forms per quarter, or 124 forms per locomotive per year. Considering the good grace with which the roads have accepted the boiler inspection law, it does seem that in States where such a condition as the above prevails something should speedily be done to obviate this superfluous drudgery. "States' rights," though properly a dead issue, still serves to inflict useless burdens as above. One of the greatest legislative needs of the railroads is not so much more or less legislation as it is uniform legislation, and it is to be hoped that a growing intensity of nationalism will at no far date serve to correct this and a multitude of other petty evils, the survivors of an era of narrow-mindedness that has no place in a unified and harmonious Government.—*The Railway and Engineering Review.*

Heart-to-Heart Talks—The Crooked Rivet

BY JAMES F. HOBART, M. E.

"Hey there, Bill!" shouted a shop foreman to a young apprentice who was poking around under a bench; "what are you looking after down there? Your reputation?"

"Naw," replied the young cub. "I'm just looking for 5 o'clock!"

"How is it with you, John and William? Are you looking for 5 o'clock, or are you trying to learn boiler making? Do you want to draw the largest salary of any workman in the shop, or are you satisfied to skimp along on the ragged edge of being fired all the time?

"John and Bill, the work you do is just as necessary as the work of the 'Old Man,' and the shop cannot get along without you two boys any more than it can without the two larger 'boys,' the superintendent and the 'boss,' So don't ever get it into your heads that the work you are doing don't amount to anything; and that as long as you rub along without the 'Old Man' catching on too often you will be all right."

"But, say, Mr. Hobart, what does our work amount to? If we don't suit the 'Old Man' he will have some more boys in our places within a week. If we work our heads off he never says anything to show that he appreciates it. Why should we do any more than we have to?"

"You shouldn't, boys. You should never do one thing more than you 'have to,' as you put it. But that 'have to' means a whole lot more than you think it does. Suppose you two boys are out for a game of baseball. You are trying mighty hard to make that South End team in the Boiler Makers' League, aren't you?"

"Sure! You just bet we are going to make that team, and we are going to win the flag, too!"

"That's right, boys. You will make the team, and you will win, too, if hard work will do it. Now, boys, you have got a pretty good team, haven't you?"

"We've got the best team in the league. John and me were subs last year, and you just bet we are going to be on the regular nine this summer. We are working for that every minute we are out of the shop."

"Good! Now, boys, let's see how that team of yours is made up? You've got a lot of lads who will work together, haven't you? Put in lots of team work, too, don't they?"

"You bet! Those boys are just like a row of rivets in a boiler shell seam. Every boy knows just what he must do, and he is all the time backing up everybody else. Oh! our nine is just great for team work. That's our strong point. That's what's going to win the pennant for us this year!"

"Just the thing, John. But, now, just look here. What will happen to that fine 'boiler seam' baseball team of yours if there is a crooked rivet in the bunch? If one of the lads don't take much interest in the game and lets chances slip by without taking them, what is going to happen then?"

"Happen? Why, Great Scott! That chap would be fired off the team in less than no time and somebody else put in his place who would play the game. That's what would happen. And happen, quick, too!"

"That's right, boys, but just look at the matter another way. Here is a big boiler-making game, of a thousand times more importance than the week-end ball game, for several hundred men are getting a living from this game. Now, boys, just look at the matter square and fair and see if it will pay you, or anybody else, to be a crooked rivet in the seam. There you are, boys, Mr. Superintendent and Mr. Foreman at one end of the row of rivets, and the other workmen lined up alongside of them, and you and William at the tail end of the row. Now, boys, can that seam be as strong as possible with one or two crooked rivets in it?"

"Sure not, Mr. Hobart; it would weaken the whole seam and boiler every time."

"That's true, boys. Now, then, don't you think it will pay to let up on the crooked rivet work and play the boiler-making game for all it is worth?"

"Y-e-s, I 'spose 'twould; but its mighty hard work backing up everybody else and just doing the odd things that don't amount to much. If we were getting a chance at the layout floor once in a while, or even a chance to run a riveter or some other machine, it wouldn't seem quite so lonesome, but to be all the time doing shack work, why, it makes a fellow look for 5 o'clock in spite of himself."

"Hold on, John; there you go again, plumb off your trolley! Say! When you are out for practice week-nights there isn't a single point in the whole game that you let slip, is there? Not a bit of practice work is too hard to be given earnest attention, is it? And don't you work harder to make yourself a good ball player than you ever work while in the shop, or ever will work while there, either?"

"Y-e-s, guess that's so. But I never thought of it that way before. It don't seem a bit like hard work, and you just bet that if shop work was like that I'd be right there with the goods every time."

"Then, John and Bill, it's just your own fault if you are not holding down the best jobs in the shop before you are 24 years old. You can do it if you want to."

"We sure want to, Mr. Hobart, and if you will tell us how we will sure try."

"Boys, do just exactly with boiler shop work as you are doing with baseball business. That's all you have to do."

"But that isn't work. We like to do baseball business. It don't make us tired as it does in the shop. If we could feel as we do when we are playing ball we could turn off a lot of work; but it's all different when we get into the shop."

"You are wrong there, boys. It is not a bit different than working in the ball field. The difference is in you, that is all. You let yourselves go to pieces as soon as you get inside the shop. You don't keep the edge on that you have when you are playing ball. Now, the shop work isn't half as hard as the ball business; and if you just make a start and make up your minds that you are going to run shop work on baseball principles you will find the shop work just as interesting. You have got to get right down to brass tacks and see that there is a mighty big chance for you and Bill in boiler making. It is a bigger chance than there ever is in baseball."

"But how can we get into that chance? I know we could do well after we got into the business and became journeymen; but how are we going to get interested in it so we can work as we do at baseball?"

"There, boys, is the keynote of the whole business. You have said it: 'How are we going to get interested in it?' Why, boys, it's the simplest thing in the world. If you will only start work to-morrow with the idea that you are going to be the two best men in the shop, and then take hold of everything with a view of finding out all about it, and finding the reasons, the why and wherefore, then you will find it just as easy and pleasant as learning to be the best ball player on the team. And you go about it in exactly the same way—just by absorbing each and every bit of 'know-how' that comes to hand, and practicing the new bits of information until you can use them by instinct.

"Then, boys, you will be doing something worth while. You will find yourselves mightily interested in every detail of the work, and with studying why and wherefore certain things are done in certain ways, and the studying out of ways and means for doing work better and quicker will very quickly be found as interesting as the latest bit of inside baseball ever proved to be.

"It's just in the way you think, boys. As long as you are thinking of 5 o'clock and a ball game, then just so long will shop work go hard, and you will wish the devil had the whole shop outfit. But just as soon as you begin to think of the work as worth while, and begin to look for interesting things, then just so soon will you get so interested in shop work that you will hanker after it just as you now hanker after baseball work.

"The simplest job in the shop will seem like new work when you get your eyes open and begin to practice for the foreman's job. And you can surely get it, too. All you have to do is to get the crooked rivets out of your head seams and the foreman's job is yours for the taking of it. Now, isn't that a game much more exciting than a one-to-nothing baseball game with the 'nothing side' at bat with three men on bases and only one man out?

"To cinch that foreman's job either you or Bill has only to know as much as the foreman does, and his job, or a better one, is yours. And you won't even have to ask for it. The job will come a-hunting you. And all you and Bill have to do is to get all the crooked rivets out of your seams. You want to know everything about boiler making. That's all you have to do.

"Now, boys, every job ever done in a boiler shop is going on all the time right under your noses, and all you have to do is to take hold and run down the ideas and the 'know-how' things which are to make you boss of the shop. All these things are going on all the time. You have only to watch for them and work out on them. Remember, you don't have to wait for some big thing to come to you. The big things always take care of themselves. Anybody can handle the big things. It's the small, insignificant ones which require skill and 'know-how,' and those are the ones you and Bill want to get interested in.

"Take, for instance, the girth seam that Bill Hawkins is driving in the big air riveter. You know two of these rivet holes don't line up. They were not punched quite fair with the layout marks. One hole is 1/8 inch 'out,' the other one nearly 3/32 inch. If this seam is driven in that shape there will be two crooked rivets close together in that important work, with only one fair rivet between the two defective ones. What should be done here, boys? Shall Hawkins let those holes go and see crooked rivets driven in them, or shall he ream those holes out larger until they are fair and drive larger rivets? In other words, shall he make the seam safe, or shall he save a little time for the shop and let the seam go with the crooked rivets in it?

"Here are some of the things you and Bill want to get wise to. And just make up your minds that it is much more important to make a safe seam than to make a safe hit. Then you will find yourselves looking into things to see why they are safe, why dangerous, and why this or that should be done, or why it should not be done. And when you get here you will be so interested in the work that all the ball teams in the State can't drag you away from it.

"You will find it mighty interesting work, the running down of reasons and the finding out 'why.' For instance, take that girth seam with the two crooked rivet holes in it. Run it down and see what caused it; how it could be prevented in future seams, and how this one can be made safe. You may find that one of the holes was laid out wrong. Or the center punch slipped a bit and the holes came a little 'off' the line. And as it happened that two holes 'off' in opposite directions happened to come together, then the error was doubled, and the pair of holes were crooked 3/32 inch.

"Or perhaps a bit of dirt, a grain of sand or a drop of forge oxide fell into one of the holes and the punch man didn't get the punch fairly centered. The result, another crooked hole. Having decided how the error happened, next we must think out some way to prevent it from happening in future. Look at the matter from all sides—'why did it happen?' It may be that the light is poor at the punch; and try as hard as he may, a man cannot be sure that the punch is fair with the punch mark. Poor light being the cause, here is a chance to improve the shop. That will be one thing for you to do after you get to be foreman.

"Perhaps Sam Longley, who runs the big punch and shear, does not have good eyesight, and that was the cause of the defective hole. If that's the case, you know how to cure the trouble when you are foreman. Perhaps it was carelessness, pure and simple, which caused that crooked rivet. Perhaps Sam was thinking of an eight-round bout to be pulled off that night. He didn't have his mind quite on the job, and that was where the error column got fat. Store this reason away, but don't wait until you are foreman to use it. Here is where you can get right in the game now and begin to make good.

"Don't mix baseball and boiler making. I never want you to think of playing less baseball than you are playing now. Hope you will make the team and be manager of it. You can do that, too, by the same method that will make you foreman of the boiler shop; but don't try to play baseball when you are making boilers. I'm sure you never miss a hit when you are at bat by thinking of how the girth seam with the reamed-out crooked hole and big rivet can never be as strong as with the straight small hole and small straight rivet; but such is the fact, nevertheless.

"You can't mend watches with boiler makers' tools, and you can't make boilers with baseball dope, so just keep them separated and don't mix them either in the shop or on the diamond. Don't give up a minute's ball practice, but lock up baseball when the shop whistle blows in the morning, and lock up the shop dope when the whistle blows at night. Meanwhile keep playing the games, boiler making and ball playing, and you will find one just as interesting as the other, and after a while, when you begin to get down deep, boiler making will prove the biggest and most interesting.

"Now, about that reamed-out crooked rivet in the girth seam; you will find a good many things you don't understand, and the way to do is to hark right back until you come to a place where you do understand and take up the trail again from that place. Now, with the defective seam; it is easy enough to understand why a crooked rivet can't hold as much as one driven fair, but why should one rivet hole, reamed out larger and filled with a well-driven rivet, why should that weaken the seam?"

"Yes, I should think it would make the seam all the stronger. Surely the bigger the rivets the more they will hold, won't they?"

"Sure, boys; but how about the sheet composing the shell of the boiler? If we space the rivets 3-inch centers, and then put in 1-inch holes, we have cut away one-third of the sheet, and the strength of the remaining plate is just two-thirds that of the unpunched sheet, the value of the plate section in that seam being 66 2/3 percent."

"That means that the larger the rivets and the farther apart the stronger the seam?"

"It looks that way, boys, but it don't work out in practice. The holes cannot be spaced farther apart than will allow the sheet between them to be calked tight, and if the rivets are too far apart the strain upon them will tear out the sheet. So there you are. We have to keep within calking distance, meaning more rivets, and then we have to see that the rivet section balances the plate section. Or it may be more proper to say that the plate strength equals as nearly as possible the rivet strength of the seam. This has been found to average about 56 inches of the uncut sheet for single riveting, 74 percent for double riveting, and 86 percent for triple-riveted butt strap seams."

"But how can I tell when the rivets are large enough to just balance the strength of the plate section?"

"There is one of the places, John, where you must 'hark back' until you get your feet on solid ground, and go ahead again from that point. If you can't figure rivet strength you must learn the method. If your arithmetic is not good enough you must study until it is. Just ask me about any of these things and we will help you out with any of them at any time. But don't be a crooked rivet."

Marine Boiler Failures

At a recent meeting of the Liverpool Engineering Society a paper, entitled "Further Notes on Marine Boiler Failures," was read by Mr. J. Reney Smith. Referring to a paper read before the Society in 1904, he said an endeavor was made to show that the great source of boiler troubles, apart from the failures due to neglect, was the distortion and alteration in form of the various parts of the boiler caused by unequal expansion and contraction. The result of longitudinal expansion was that as the front and back plates prevented an increase in the length, the furnace was compressed and the corrugations were closed, the effect being greater on the upper than on the lower part of the tube. Simultaneously there was an increase in the vertical direction with a combined result that the furnace was flattened, the flattening being greatest at the combustion chamber end where the corrugations were exposed to the greatest heat, and where, in fact, the furnace usually failed. The effect was most marked in a double-ended boiler with a combustion chamber common to two furnaces. Here the furnaces and chamber might be considered as a beam securely held at each furnace mouth. The effect of expansion in this case was distortion of the furnaces, together with a sagging effect and consequent failure of the back tube plates and saddle corners, due to the comparatively weak forms of these plates below the lower stay tubes. The inevitable bill for repairs could be materially cheapened by adopting a method of attachment for the furnace backs which would permit a renewal of a furnace at a comparatively low cost. The back of the furnace was contracted in area, the corrugation tapering off in a bottle-neck shape and being flanged outwards to join the saddle piece, which was secured to the tube plate and combustion chamber.

Many serious troubles were due entirely to the great differences of temperature between the lower third of a boiler and the upper two-thirds. It was found that this difference could amount to as much as 270 degrees F., which meant that in a double-ended boiler 18 feet long the variation in length would amount to nearly ½ inch. Worked out, this gave an equivalent of 13 tons per square inch as an extra stress to which the lower third of the boiler was subjected. The large percentage of cracked lower seams and leaky joints in this part of the boiler was undoubtedly due to this cause, and occurred more frequently in double-ended boilers.

When cracks were discovered in a comparatively new boiler, cutting out and renewing seemed in most cases to be the only alternative to patching, which was a most unsatisfactory method of covering a crack, especially in places where uniformity of section was essential for the proper transmission of heat. A new system was that of welding the cracks, or rather filling the cracks with new metal brought to a welding heat by the oxy-hydrogen or oxy-acetylene method. But some difficulties were experienced in using this system, and consequently electric arc welding had made a rapid advance in favor, and was the system now generally adopted for this class of repair. In the Bernados system an ordinary electric light carbon was connected to the positive main from the generator, the metal to be heated being joined to the negative main. In manipulating the tool the carbon was touched against the metal near the part to be welded and drawn a short distance away, when the electric arc was struck and the metal quickly heated. The arc was about 4 inches to 4½ inches in length. In about twelve seconds the required temperature was produced, the arc was removed, and the weld hammered in the ordinary way. There was an objection, however, to the use of carbon, as it was found that a certain proportion combined with the welding metal, the result being that a material was produced similar to cast iron, and therefore unsuitable for boiler work. Pommee, of Hamburg, recognizing the disadvantages of carbon, experimented with the system developed by Messrs. Albrecht & Dantz. The principal feature in this method was that the iron welding pencil itself formed one pole, while the part of the boiler where the work was being done formed the other. An advantage was the avoidance of great heat in confined spaces, as the enormous temperature of the electric arc rapidly brought the small point on the surface being dealt with to a welding heat, the point of the iron pencil simultaneously rising to the same temperature when a drop was deposited upon the work and combined with the metal heated to receive it. The drops followed one another in quick succession until the fracture was filled and the work completed. The objections to heating the plates over a large area were thus avoided, for although the temperature was high (about 3,500 degrees C.) it was rapidly produced, and the work was finished before the heat was transmitted to any extent to the surrounding metal. The method of dealing with local wasting of the plates was simply building up to original thickness the plate where wasted. It was necessary to remove the oxide or dirt by first chipping to bare metal and then, drop by drop, to add to the thickness until something over the original scantling was reached.

Boiler Inspection—Its Responsibility in Relation to Manufacturer, Owner and Boiler Inspector

BY J. T. BRADBURY

Boiler inspection in the countries and States where it has been adopted by the Legislatures as a compulsory measure, easily takes its place in the front rank of modern systems for the protection of life and property.

Industrial conditions, with their ever-increasing demand for higher boiler pressures, in carrying on the work of manufacture and transportation, make it more imperative than ever before that a campaign of agitation should be commenced with a view to impressing on the governing bodies, and those vitally interested, the very great importance of thorough steam boiler inspection and its ultimate adoption, thereby perfecting a system that must commend itself to every practical mechanic who has anything to do with the manufacture or care of steam boilers.

From time to time the world is aroused from its state of lethargy by the startling report of some horrible catastrophe such as the foundering of the White Star liner *Titanic*, with its awful toll of over 1,600 human lives, bringing us to a realization of the fact that we have been living in a sense of false security, and also proving that modern systems of transportation have not yet reached that stage of perfection as to render them immune from accident or loss of life. If the method of inspection had improved in proportion to the improvement in the building of great ocean steamships this terrible calamity would never have happened. As it was, the same regulations were in force for this ocean monster of over 60,000 tons as were used for the vessel of 10,000 tons, and as a result there were only enough boats to take care of about one-third of her passengers. Fortunately such a horrible disaster could not possibly happen by the explosion of any boiler or boilers, but enough lives are lost and damage to property sustained every year to give those responsible cause for more serious concern than has yet been shown.

The responsibility of the manufacturer in the country where government inspection is not compulsory, to my mind, is great indeed, as in competing for business he very often is indifferent to the necessity for efficiency in the product of his shop, and sacrifices that important principle in order to make a profit on his labor.

These boilers often go out in the country to run small portable sawmills, and are never tested for years, and when any repairs are necessary a blacksmith is quite often called in to do the job. Under a system of inspection such a state of affairs could not exist, as the boiler would be examined every year, and any defects developing would be looked after at once.

The responsibility of the owner or manager of every plant using steam boilers is equally as heavy as that of the manufacturer, as he is the man to see that the recommendations of his engineer are carried out. A steam boiler is not a plaything by any means, and if repairs are necessary any old "Jack of all trades" is not able to do the job, neither is a blacksmith or machinist; but it should have the expert labor of a competent and experienced boiler maker.

I have seen many a good boiler almost ruined by just such treatment as described above, the owner having to pay a heavy bill for poor work, and in the end have to secure the services of a boiler maker, making the job cost double what it should have, without taking into consideration the injury to the boiler.

In regard to the boiler inspector and his share of the responsibility I should say he shoulders the heavier portion, as on his knowledge of figuring out the efficiency of each job, coupled with practical experience, depends the working of this all-important method of modern legislation. No great reform has ever taken place that has not met with the most strenuous opposition by those most deeply concerned, yet we have not heard of any desire on the part of those who have adopted compulsory steam boiler inspection for a return to the old conditions. It is like a great many other changes that take place in everyday life, which at first seem to be too radical to commend them to the public, yet in the end prove to be blessings in disguise.

When one stops to consider what it means to manufacturers and corporations to render obsolete many boilers that have only done one to three years' service, and that looked good for a great many years, if compared with service of similar boilers under the old order of things, just to fulfill the requirements of the law, will give some idea of the great change that took place in the State of Massachusetts when that Legislature adopted State boiler inspection. I understand that the great majority of steam users in the State were only too pleased to co-operate with the State Boiler Commission in their efforts to perfect this important work.

In the province of New Brunswick, Canada, where I live, there is a Factory Inspection Act, under which head boiler inspection is supposed to be operative, but which in reality is only a farce, meaning nothing at all, as any boiler maker or stationary engineer with five years' experience in the care of steam boilers is deemed capable of granting a certificate of efficiency after a specified hydrostatic test, without any examination as to qualification or ability to figure out the working pressure according to regular formulæ.

In order to illustrate the great (?) hold it has taken on our business men, I will mention a couple of incidents in my personal experience as showing the utter indifference on the part of those who should be deeply interested (as they have the most at stake) when called in to examine the boilers in their respective plants.

I was ordered one day by my employers, shortly after I took my present position, to examine and test the boilers in a certain factory in the city. Arriving at the plant, I went to the boiler room, expecting to see everything in readiness for examination. The machinery was running and everything going full blast, that fact alone causing me no little surprise. I was beginning to think I had made a mistake and struck the wrong establishment. Asking the engineer if this was Mr. So and So's factory, and receiving an affirmative answer, I then asked him if he had sent to the shop to have the boilers inspected. He informed me the boss had. "My dear man," said I, "you surely cannot be serious if you expect me to inspect and test these boilers with the fires going and 100 pounds of steam?" He replied by saying that he had objected to it ever since he had been on the job, and hoped some day to see it different, but the factory inspector (who, by the way, was a grocery man) had told him it was a mere matter of form and of no importance whatever; they had been doing it year after year, and would likely continue to do so.

I asked for the proprietor, and was directed to the office. After introducing myself and stating my errand, he produced a form for me to sign, which form certified that I had tested their boilers at so many pounds hydrostatic pressure, and found everything in first-class condition. Asking him if he thought I would sign such a document without doing the work that was specified, he informed me they had always had it done that way and expected me to do the same. I very properly refused, saying to the gentleman I would be performing a criminal act were I to sign my name to a paper of that nature without complying with the conditions named thereon. I therefore left the establishment, and suppose some one else supplied the necessary guarantee that everything was in first-class condition.

On another occasion I was sent out to examine and report on the condition and necessary repairs required for a battery of cylindrical mill boilers of the shell description, without flues or tubes, 33 inches in diameter and about 60 feet long.

On entering the boilers I discovered that they had never been cleaned out and were covered with a coating of mud and scale, which in some places varied from one-eighth to one-quarter of an inch in thickness. I told the engineer I could not examine the boilers in that condition, and ordered him to have them thoroughly scaled and cleaned from the waterline down, and to let me know when he was ready for inspection.

A week or so later word was sent for me to come over to the mill. Going into the boilers again I was surprised to find that very little had been done toward carrying out my recommendations for scaling and cleaning boilers. Asking the engineer why the work was not done, he said he thought he had done all I asked him to do.

I told him I would go through the boilers and make a partial report on their condition, and finish when he had followed out my wishes in regard to cleaning and scaling. The first blow with the pean of my hammer on a rather shaky looking place resulted in my hammer going clear through the plate, revealing to any practical man a very weak and defective condition. The same thing happened a little further along, which caused me to sit up and take notice. I could, if I desired, put the pean of my hammer through any part of the bottom of the first boiler. The next turned out very little better.

Coming out of the second I was confronted by the owner and manager, both looking rather serious. It appears that one of those faithful (?) individuals commonly known as a "sucker" was nosing around, and hearing the noise in the boilers, scented a chance to get in some fine work, flew to the office and piped off the boss, likewise the manager, that explaining the reason for their presence outside. The manager informed me that he did not want the boilers punched full of holes, but only to find out what repairs were necessary, in order to have everything ready for work in the spring. I then asked him if he wanted me to find any defective spots; his answer was, do as we always did, let the steam find them. After such a tip as that, and coming from such a source, one could not help but feel that although he might be in the right church he certainly was in the wrong pew, so acting on the impulse of the moment I commenced to take off my overalls, at the same time remarking to the manager that he happened to get the wrong man, and ought to have had a plumber.

He insisted, however, on my continuing, only doing the job whatever way I thought right. On those conditions I changed my mind, examining the whole lot in a fair and honest manner, and as a result sent in a report that ought to have put the battery in the scrap heap. Those boilers had been running over fifty years, being made of iron, with not a single double-riveted seam in the whole job, and figuring up from our present marine regulations were not safe to carry any more than 65 pounds when new, but instead of that were carrying 85 pounds. I never made any further report, the owners fearing, no doubt (and quite correctly, too), that if the boilers were thoroughly scaled and cleaned additional defects would have been disclosed; consequently our recommendations and services were dispensed with, a new crew called from another shop, who put very extensive repairs on the job, and the boilers are now running every day, a menace to the safety of a large number of workmen.

Were it not for the inspection carried on by the insurance companies I firmly believe there would be a very much larger number of failures to record annually. The fact that insurance companies recognize the importance and value of steam boiler inspection, with its consequent expense, as a good investment, ought to be the strongest argument in favor of government adoption in every province of the Dominion of Canada and of every State in the Union.

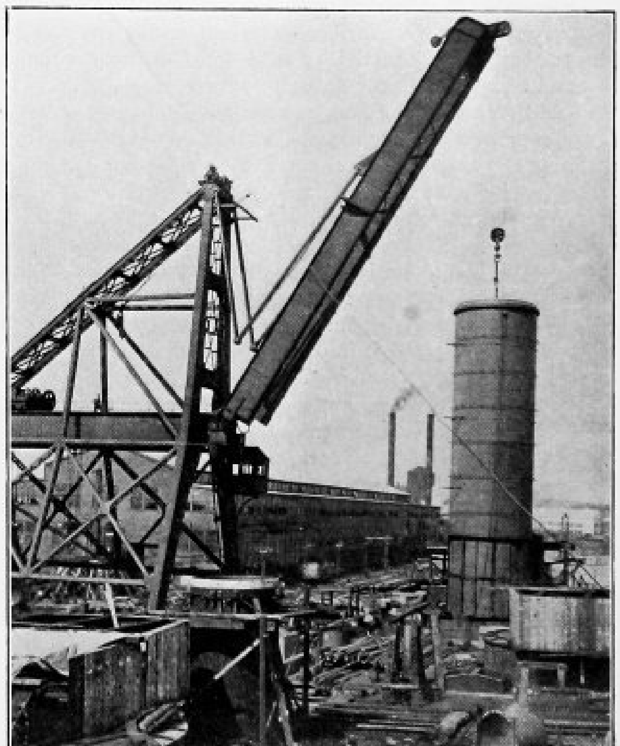
A reasonable limit I think should be placed on the life of every boiler, and that limit should be regulated in proportion to the working pressure and the conditions under which the boiler or boilers have been working.

I am sure those in authority would not hesitate very long if they only knew of the large number in service throughout the country districts that are a menace to public safety, but would realize the urgent necessity for legislation along those lines.

I hope that some one else will take up this important subject, and give it the publicity such a measure requires, in order to educate those who at present are blind to the need of such a law, and putting into general effect another system for the protection of life and property.

Smokestack for a Dreadnought

With the increase in size of the latest battleships, especially those now building by the Fore River Shipbuilding Company and the New York Shipbuilding Company for the Argentine Government, the construction of the funnels becomes an unusually large piece of work for steel plate shops. The photograph shown herewith is a picture taken at the Fore River shipyard, Quincy, Mass., showing the placing of the after stack on board the Argentine battleship *Rivadavia*. This stack is 58 feet 4 inches long, 14 feet 6 inches diameter, and weighs 26 tons.



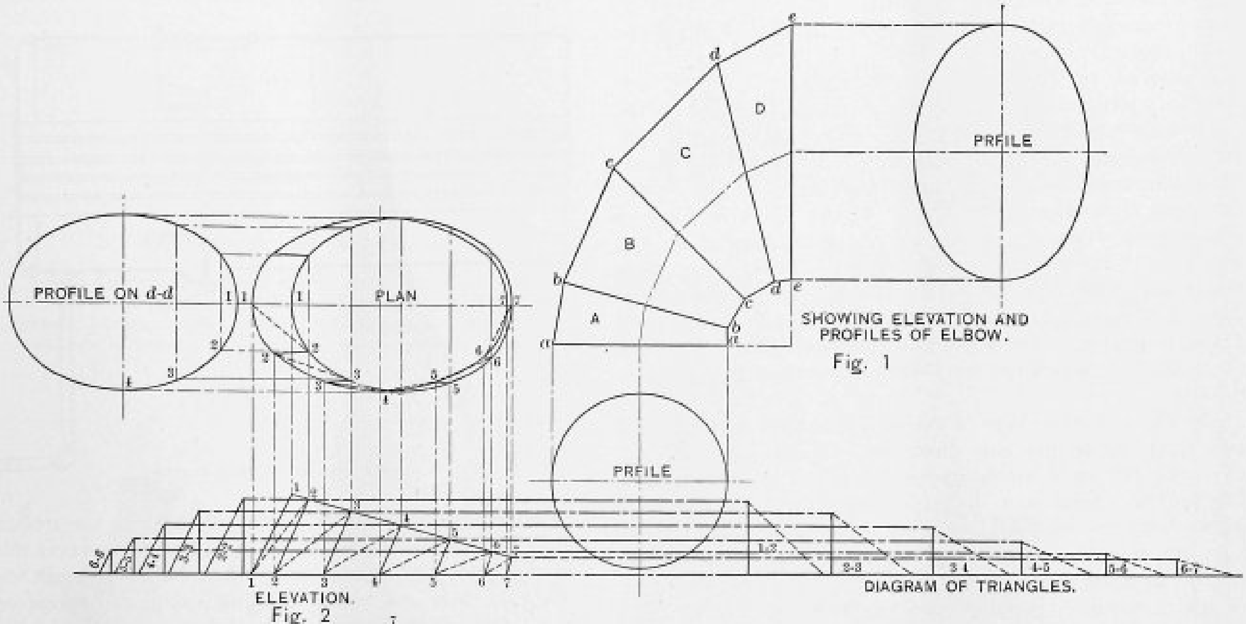
PLACING A 38-TON SMOKESTACK ON BOARD A BATTLESHIP

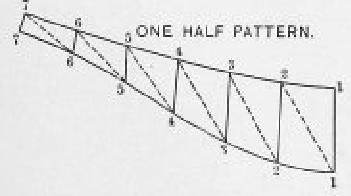
Development of an Irregular Elbow

BY C. B. LINSTROM

One of the problems met with quite frequently in the shop is the layout of elbows of one form or another. The regular elbows are probably the ones used the most. In developing these regular forms no difficulty is encountered unless the elbow is oblique to the principal planes of projection. But in such a case the problem can be readily solved by simple steps of projection.

Elbows of an irregular shape and tapering from one profile of one kind into that of another require sometimes a lengthy





series of operations in developing the required patterns. This is especially evident in constructions where the elbow is spirally formed; that is, the pipe runs around another of a larger size, as a helix, and where the rise or fall is sometimes equal for each section or irregular as required. Pipe elbows of this kind are usually used in blast furnace work, as in a downcomer. Each section in such a construction is oblique to all planes of projection.

In all cases of this character where the patterns are required, each section must be revolved around into a plane which will show the pipe section in its true length. It is also apparent that to obtain the required twist and the required rise or fall of each section, the miter lines between each section must be carefully determined, otherwise the result would be that when the pieces are assembled the elbow would be straight.

Other conditions enter into elbow problems, various forms and irregularities in profiles are met with. Some taper from a round to a square, rectangular, elliptical and wash boiler sections, but any combination of these profiles can be used. The development of any arrangement that might be made are practically alike, and the layer-out who has a practical knowledge of the application of the "triangulation development" will find it to his advantage that he does understand the system, as little trouble will be found in securing layouts which are approximately correct and practical.

Fig. 1 of this article represents an elbow tapering from a round section into an elliptical one. The major diameter of the ellipse is greater than the diameter of the circle. The minor diameter is equal to the diameter of the circle. The elbow in this case is made up of four sections—*A*, *B*, *C* and *D*. Each section is irregular and requires a separate lay-out, as the

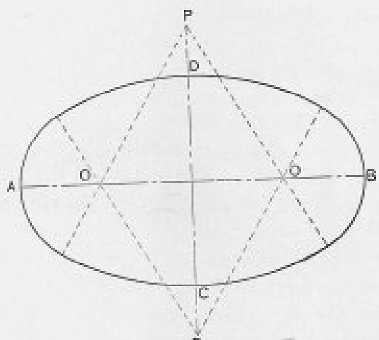


FIG. 3

profiles through the planes *d d*, *c c*, *b b*, etc., are of different form, owing to the taper and shape of the profiles.

Before entering into the discussion of Fig. 2 a method for constructing an approximate ellipse will be given, which is of value, since ellipses must be drawn for each profile through the planes *c c*, *d d*, etc.

CONSTRUCTION OF FIG. 3

A-B equals the major diameter of the ellipse. *C-D* equals the minor diameter. From *A* and *B* set off distances *A-O* and *B-O* equal to less than one-half *A B*. With *O-O* as centers and with the dividers or trammels equal to the distance between them, draw arcs intersecting as at *P* and *R*, respectively. Draw lines from *P* and *R* to *O-O*. If the work has been accurately done, sides *O P*, *O O* and *O R* should be equal. With

P as a center and the dividers set to a radius *P C*, draw an arc of an indefinite length, and from *R* as a center and with the same radius draw an arc through *D*. With *O* and *O* as centers complete the ellipse by drawing arcs through *A* and *B*.

CONSTRUCTION OF FIG. 2

This figure shows the development of section *D*. The remaining sections, *A*, *B* and *C*, are developed in a like manner. Transfer the section *D*, Fig. 1 to Fig. 2, as shown in the elevation. Bisect the top and bottom lines of the elevation, as at points 4. Erect perpendiculars therefrom, then at right angles to either perpendicular draw a horizontal line. Upon these lines as axes construct the plan. Some preliminary drawing must now be done in order to show correctly how the top of the section will appear, since the plan is inclined to the horizontal plane. Owing to the inclination the top through its major axis will appear foreshortened in the plan. The minor width, however, will appear in its true length.

To the left of the plan view at a convenient distance, construct a profile through the plane taken on line *d d* by the method explained for constructing Fig. 3. Divide its circumference into any number of equal parts, and from these points draw horizontal lines of an indefinite length. Then on the elevation locate the points 2, 3, 5, 6, etc. This is done by transferring from the profile the distances located on the major axis. An inspection of this figure will show how these points were found. From the points 1, 2, 3, 4, 5, 6 and 7 draw vertical lines until they intersect the horizontal ones previously drawn in the plan. Their points of intersection determine the points through which the foreshortened curve of the ellipse is to pass.

The ellipse for the base of the section is then drawn in full size according to previous directions. Divide its circumference into the same number of equal spaces as contained in the profile. Solid and dotted construction lines are then drawn between the points of division on the ellipses. Solid lines join the points 1-1, 2-2, 3-3 to 7-7, inclusive. Dotted lines are drawn from 1 to 2, 2 to 3, 3 to 4, etc. The corresponding construction lines are then drawn in in the elevation. This is the best practice, even though it does involve extra labor, because it aids the layer-out to check up his work after he has laid off the pattern. The triangles at the right and left are drawn for the purpose of finding the true lengths of the dotted and solid construction lines. The bases for the solid lines are equal to the distances 1-1 to 7-7, inclusive; those for the dotted are equal to the dotted distances of the plan. The relative heights are shown projected from the elevation. The lines joining the bases with heights are the true lengths of the lines required.

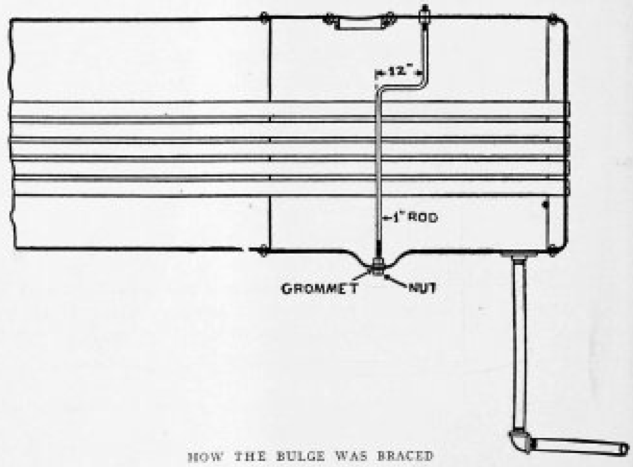
DEVELOPMENT OF PATTERN

One-half of the pattern for section *D* is shown developed. The triangles are assembled in their relative positions according to the numeral notations placed on the drawing. The distances between the triangles at the top of the pattern are equal to the chord distances between the spaces of the profile; those at the bottom are equal to those of the profile on the large ellipse.

A Bulged Boiler Repaired

In a certain plant below the Mason and Dixon line, where the main purpose of operation is the extraction of a golden stream of oil from cotton seed, the attention of all hands was so firmly fixed on the main issue that less important details were slighted. Among these "details" happened to be the boilers. They had reposed for years in their allotted position, humbly digesting any and all of the fuel supplied and absorbing most of the water generously if spasmodically injected by the gentleman of color who attended their wants. As far as that end of the institution was concerned he was supreme and satisfied all requirements so long as enough of the mysterious gas was provided to drive the presses which produced the golden stream.

Whether the patient boilers ever suffered from indigestion or other complaint is not known, but one at least seems to have been afflicted by an irritation of its enveloping cuticle which resulted in a "rise" or "bulge" of distressing dimensions. For when subsequent results finally forced attention the affected spot was about fourteen inches diameter and in it the material had been pressed out four and one-half inches from its normally smooth contour. It is probable that this trouble was of a gradual development unobserved by the aforesaid attendant amid the exactions of more important duties. Perhaps he did notice the swelling, but either failed



HOW THE BULGE WAS BRACED

to realize its seriousness or postponed too long the treatment for its alleviation. However this may be and however mixed our metaphors, the time came when boiler strength could endure no more and, either in a final spasm of distress or in one mighty effort for relief, the bulge was burst and one boiler's contribution to the golden stream interrupted.

Now up to this point the narrative may appear but the record of a commonplace and well-understood boiler failure. We admit all this and that as such it is not of sufficient interest to justify its appearance in *The Locomotive*. But there is more to come; and as that "more" involves a most ingenious as well as a most ingenuous method of boiler repairs, we have felt it of value to our readers to set forth all of the circumstances.

Of course, the bursting of the bulge, with its attending diminution of the stream of oil, was a disaster that demanded immediate action, and the lack of an available substitute boiler clearly indicated that such action must be directed to the repair of the disabled vessel. Boilers, as a class, however, were scarce in that particular town and the demand for a specialist on their ills and remedies not sufficient to attract such a one to the neighborhood. Apparently, however, a general practitioner was at hand and his services secured.

To this man the remedy to be applied seemed obvious, or so his subsequent action would indicate. A hole had been blown through a bulge in the bottom of the shell and that hole must of course be plugged in some manner if the boiler was to retain water and steam. But further, that bulge was an evidence of weakness and that weakness must be reinforced or the bulge would continue to increase and eventually burst again. Clearly the steps to be taken must both stop the leak and prevent any further strain on the affected spot, and the scheme outlined in our illustration appeared at once to successfully meet both conditions. The idea was evidently to prevent the bottom of the shell from straying farther by

tying it to the top and by the method of securing the tie or brace to cover the rupture.

The general practitioner accordingly, with commendable skill, proceeded to prepare the hole in the center of the bulge for the passage of a one-inch rod on which threads had been run at either end. This rod was then passed up through the hole and between the tubes to the top of the shell, where a second hole was to be drilled directly over the bulge. But here the fates were against him, for on opening the man-hole the first thing that appeared was the end of the rod projecting vertically from the lower sheet to near the center of the man-hole opening. Clearly at this point no convenient material existed for drilling a hole. But the situation was not insurmountable. If the rod could not be fastened at one point, why, of course, it must reach another where better conditions obtained. So a new rod was procured of a length sufficient to permit of the necessary offset, and this second rod secured by grommets, nuts and check nuts, both to the bulge and to the top of the shell at a point where the man-hole could not trouble.

The success of these repairs was unqualified, at least in the mind of those who continued the operation of the boiler through that season's production of the golden stream. The aforesaid attendant continued his attention to his charges with full confidence in the protection of that brace, and the general practitioner went on his way rejoicing at another deed well done. It is not surprising under such circumstances that an officious boiler inspector who visited the plant the following year was generally criticised for requiring the removal of the brace and the heating and setting back of the bulged plate to its original position, with a patch covering the hole.—*The Locomotive.*

The Locomotive Boiler Inspector

BY GEORGE AUSTIN *

The development of the modern locomotive during the last few years, including as it does increasing steam pressure, larger boilers and requirements of a more exacting service, has brought with it problems of far greater importance to the boilerman than was the case with the early types of locomotive boilers and engines.

When steam pressures began to be increased from 120 pounds per square inch—which was the average steam pressure on locomotive boilers during the seventies and early eighties—we began to be troubled with broken stay-bolts. The larger the boiler and the greater the pressure the more trouble was experienced with broken stay-bolts.

This brought out specialists—men who were especially trained to detect these defects—and these men were known as stay-bolt testers or tappers. Of late years these men, formerly known as stay-bolt testers, have been known as boiler inspectors, and it is with the idea of assisting in the improvement of our boiler inspectors that this article is offered, as being a practical general line along which they should work and to call their attention to the possible opportunities there are of developing into authorities on the care and maintenance of locomotive boilers and fire-boxes.

I will begin by saying that no part of the locomotive boiler or fire-box will wear out quicker than another part if it receives equally as good treatment. To cause a fire-box sheet to begin to crack or bulge it must previously have been overheated. The same statement applies to flues or seams, and, this being true, it is only reasonable to assume that, having found such a condition developing—that is, one part of the fire-box sheets showing more rapid degeneration than the others—the boiler inspector should look for the cause.

The evidence of rapid degeneration of a fire-box sheet usually is pretty clearly shown on the fire-side, usually by leaky stay-bolts, a slight cracking in the stay-bolt holes or a slight bulging of the sheets between the stay-bolts. This very frequently is the case with door sheets. Sometimes it is found in the crown sheet or in the side sheets, and in almost every case investigation shows that it is caused by overheating, and is due to one of two things, either to scale and mud forming on the water sides or to improper drafting, either at the smoke-box end or the back end, or both.

We rarely find all the parts of a locomotive fire-box showing equal evidence of wear or overheating or rapid deterioration. Usually there are one or more parts that show up worse than the others, and there is a cause for this, and that is what the boiler inspector should find out.

The boiler inspector prides himself on his ability to detect broken or defective stay-bolts. Of course, it is very essential that he become highly efficient in that art, and, having become so, it is perfectly natural he should take pride in the accomplishment. From my point of view such work is only a part of his duties, and it is just as essential that, when inspecting a fire-box, he note the fact that portions of it are not running as well as the most of it, and it should excite his apprehension that something is wrong.

A great deal of this trouble is due to poor boiler washing, scale being allowed to accumulate around stay-bolts and on the plates until it has become so heavy as to keep the water away from the metal, causing overheating. We must assume that, even with the best water on the Santa Fe for locomotives, there is a continuous formation of scale, some of which is very dense, and a comparatively thin layer, not one-sixteenth of an inch thick, is liable to cause overheating under conditions which may concentrate the flame at any one point. This is sometimes caused by a banked fire, at other times by a dirty fire, and again it is caused by improper drafting.

Take the case of fire-door sheets that show unusual stay-bolt leakage or bulging between bolts. Investigation often discloses the fact that the deflecting sheet was run too high, that an excess of overdraft was produced, and that too much of the fuel was being consumed at the back part of the fire-box. At other times it would be shown that scale or mud was forming.

Take the case of some engines giving unusual trouble with flues leaking. Investigation probably would show there was not sufficient overdraft. I do not presume to give a definite statement as to just what is the cause of the unequal drafting, but the conditions certainly point out that there is something wrong with it, and it should be the care of the boiler inspection at least to report that condition and have it investigated.

The boiler inspector should at all times realize that it is his particular duty to prevent the necessity for repairs, which can be done only by observing carefully the condition of any fire-box he inspects, looking particularly for unusual developments. It does not enlighten us any to say that a cracked side sheet or door sheet is due to contraction or expansion.

* General boiler inspector, Topeka, Kan.

Everyone knows that. What we would like to know is what caused this particular expansion or contraction, and if our inspector can tell us he also very likely knows what to do to prevent it.

A locomotive may be a good steamer, may be economical on fuel—may be entirely satisfactory in that respect—and yet may not be properly drafted (*i. e.*, from the standpoint of equal distribution of heat), and it is this unequal distribution of heat in the fire-box, in connection with the deposit of scale or mud, that develops these defects in one part of the fire-box more than in another, whether it be side sheets, door sheet, crown sheet or flue sheet, and, when we consider the fact that the hotter a fire-box sheet is the greater the evaporation, and consequently the greater the incrustation at that hot point, due to the greater evaporation, it is not difficult to understand why overheating occurs when heat is not evenly distributed in a fire-box.

It is to conditions of this kind that I especially invite the attention of our locomotive boiler inspectors. They should be continually on the alert to detect such conditions and striving to improve them. An inspector developing himself along these lines adds to his value, and the time must come when his services will be appreciated.

In an average roundhouse there never is a time there is not something he can inspect; there never is a time when there is not some problem that should be calling for the exercise of his judgment and ability.

In the inspection of the interior of the boiler he should be thorough and painstaking, always on the lookout for defects. Superficial inspection is of little value; he must examine closely. He must look for cracked side sheets, broken brace pins and missing cotters, and must see that the water spaces are clean and free from scale.

He must be particularly careful to examine along mud-rings and to remove all rivets, bolts and tools that may have fallen. He must see that the scale is scraped away from all parts of the interior, so that there is no possibility of any defect being hidden. He should interest himself in the condition of the flues, to see that they are properly cleaned and that the beads are properly set up. He should know the air spaces in the grate-bars are free from cinders and that external corrosion is not taking place behind the side bars.

With the ash-pan and grates he should be thoroughly in touch, noting that the grates operate freely and with a full opening without excessive lost motion; that the ash-pans are tight and that the slides operate freely and close properly to avoid the probability of dropping fire. He should examine the brick arch tubes, and should know whether any roughness is apparent on the outside, which condition denotes the formation of scale on the inside.

He should inspect thoroughly the front end appliances, and should know that they are secured properly to prevent the throwing of fires. He should know that the front end and the hoppers and plates are tight and do not admit air to the smoke arch. When the boilers are being washed he should inspect the interior carefully, and should see to it that they are being cleaned properly.

It is the constant practice of his profession in inspecting these parts that develops in him the ability to quickly comprehend the condition of a boiler or fire-box, and his expertness and reliability along these lines give him a standing with his superiors that can be acquired only by the thoroughly competent man. He will find that his efforts will be rewarded to the extent that he will be accepted as an authority, and if his immediate superior or anyone else interested wants to know the condition of a fire-box or boiler he will feel satisfied that the decision of that particular boiler inspector is as good as anyone can give, and it is very gratifying to one to have established for himself a standing of this kind.

The writer in his lifetime has noted and experienced the growing importance of the locomotive boiler inspector. As a result of that experience and observation he does not hesitate to predict that the boiler inspector has not nearly reached the height of his importance or value to the railroad or to himself. He must, as he improves in value and proves his value, strengthen his position and increase his reward, and in proportion to the expertness he achieves and the confidence he creates in his reliability will he be rewarded. There is no getting away from it.—*Sante Fe Employees' Magazine.*

Mechanical Stoker*

The committee pointed out last year that the principal benefit to be derived from the utilization of a perfected stoker fulfilling the requirements specified was the realization of the maximum boiler capacity of locomotives with the ultimate result of increasing their hauling capacity and reducing their cost of operation per ton mile of service rendered.

The actual service performance of two stokers complying with the specifications laid down in last year's report, as developed by extensive inquiry among railways which have heeded the committee's request by lending their aid and installing a limited number upon large locomotives, justifies the committee in now reporting that these two stokers have, in a measure, fulfilled its expectations, inasmuch as the indications are that their service has been sufficiently reliable in practical operation on a large number of heavy locomotives. These stokers are the Crawford Underfeed Stoker, which was described in the American Railway Master Mechanics' Association Proceedings for 1910, Vol. XLIII., and the Street Overfeed Stoker described in the American Railway Master Mechanics' Association Proceedings for 1910, Vol. XLIII.

Both types of stokers in successful service to-day maintain the same general principles in design originally employed. The improvements made on them, which resulted in making their operation practicable, are improvements of detail only, such as would result from the knowledge gained of the weaknesses of individual details brought out by actual service.

As the greater sustained tractive efforts of the large engine equipped with superheaters and brick arches is gradually taken advantage of, its fuel consumption per hour will increase, though decreasing on the ton-mile basis, with the eventual result of possibly making necessary to some extent means, in addition to those already provided, to supply fuel to the engine up to its maximum requirements. When this condition develops, as it is bound to, by traffic increases, careful investigation of tonnage ratings, and the raising to a higher standard the efficiency of operation, the demand for a perfected type of mechanical stoker will become more acute than ever. It is, perhaps, somewhat of a good fortune that the superheater has stepped in and tided over the difficulty that would have resulted while the stoker was in process of development and the demand for large engines becoming more insistent.

Crawford Underfeed Stoker

This stoker, in service on the Pennsylvania and the Baltimore & Ohio, has been developed into a practical operating machine, and is being applied to all of the large Pacific type class K-2 passenger locomotives and the consolidation class H-8-C freight locomotives building for the Pennsylvania lines west of Pittsburg. On these lines forty-five locomotives are now equipped, and twenty locomotives under construction are being equipped. The lines east have ten locomotives equipped.

* From report presented at the Master Mechanics' convention, Atlantic City, June, 1912, and published in the daily edition of the *Railway Age Gazette*, with whose permission the above abstract is reprinted.

The Baltimore & Ohio reports one Crawford stoker in service on a Mallet engine with a grate area of 100 square feet and a tractive power of 105,000 pounds, working compound.

The forty-five locomotives on the Pennsylvania lines West, which include some of the earlier designs, have made a total of 7,361 trips up to the middle of March, of which 3,640 were 100 percent stoker-fired, 2,082 between 75 and 100 percent and 1,639 below 70 percent. The percent stoker-fired is in reference to the amount of coal put into the fire-box by the stoker; as, for instance, a 90 percent stoker-fired trip means that the stoker fired 90 percent of the coal while 10 percent was hand-fired, the firing by hand being done to fill up spots in the grates which resulted from imperfect distribution of the coal by the stoker. Some capacity tests on the Western division of the lines West were run with a dynamometer car on various passenger locomotives, one of which was a Pacific type equipped with a Crawford stoker. The results of these tests have not been completed so as to become available for this report, but the preliminary figures indicated, with respect to the coal consumption, that the stoker made as good a performance as the skilled fireman selected for the hand-fired locomotives.

The Crawford stoker applied to the Mallet engine of the Baltimore & Ohio has been in service about a year. Some difficulty was experienced with this stoker, due to the fact that some departures in design were made from the stoker as originally developed, consisting principally in the provision of two cylinders to operate the plungers instead of one. This necessarily added certain complications which subsequently gave trouble. After certain changes the stoker gave a fair distribution of coal. This stoker is still in service, but has not given quite the satisfactory performance so that it could be termed unqualifiedly successful. Inasmuch as this particular stoker is a modification of the Crawford stoker, as now perfected for engines of the type to which it has been applied on the Pennsylvania lines, some difficulty, as experienced with it, might reasonably be expected.

Street Overfeed Stoker

This stoker is now being built in two somewhat different forms, distinguished from one another as the screw conveyor type and the crusher type. The screw conveyor stoker is built to take screened coal from the tank and distribute it evenly over the grates in the fire-box without being handled by the fireman. The coal used by this machine must be passed through a screen having 2-inch square mesh before it is placed in the tank. With this type of machine the fireman has no manual labor to perform excepting that of raking the coal on top of the screw conveyor when the supply in the tank is low.

The crusher stoker is designed to take lump, run-of-mine, or slack coal from the tank and distribute it over the grates in the fire-box. With this type of machine all the coal must be scraped or shoveled into the crusher by the fireman. The parts of the stoker on the back boiler head and the distribution systems are the same with both machines. The primary difference between them is in the means provided for conveying the coal from the tender to the distribution system, the screw conveyor type only needing one engine to operate the entire machine, whereas the crusher type needs two: one for the crusher, the other for the conveying mechanism.

It is the opinion of the designer of the Street stoker that the provision of means for preparing coal on the tender for suitable firing is but a temporary expedient to be used with experimental machines, and that for practical operation of a large number of stokers it would be more feasible to prepare the coal at the chutes suitable for stoker firing before delivery to the tender. The committee last year recommended that a stoker, in order to be complete, should be able to handle run-of-mine coal. In this respect the Street screw conveyor of stoker does not meet the committee's recommendations. The indications, however, are, judging from recent developments, that it will be more economical to concentrate the means for properly preparing coal for stoker consumption at the coal chute with the net gain of reducing to a minimum the complication of a machine which, when applied to a locomotive, will of necessity add to the expense of locomotive maintenance and the likelihood of engine failure.

There are thirty Street stokers applied and in service to-day, thirteen of which are of the crusher type and 17 of which are of the screw conveyor type. Sixty-nine stokers of the screw conveyor type are under construction for application to forty-five Mallet engines, ranging in tractive power from 72,800 pounds and 99.5 square feet grate area to 105,000 pounds tractive power and 100 square feet grate area, and twenty-four Mikado engines of 60,800 pounds tractive power and 66.7 square feet grate area. The thirty stokers in operation are applied to engines ranging in size and type from 45,700 pounds tractive power consolidation freight, 58,000 pounds tractive power mountain passenger, and 60,700 pounds tractive power Mikado freight to 105,000 pounds tractive power Mallet freight and pusher engines. At the last convention of this association eight of these stokers were in operation. From the service rendered by them, as well as the results of individual investigations made by various roads, this number has grown to thirty, with sixty-nine under construction for entry into service within the next few months.

General inquiry of different roads which have the latest type of Street stoker in service has developed the facts that its service is satisfactory, as indeed is attested to by the extension of its use; that it permits realizing the fullest capacity of the locomotive boiler; that it permits of carrying a thinner fire than ordinarily possible with hand firing; that with considerate attention it renders practically uninterrupted service; but that it does not necessarily effect economies in fuel consumption. The fact was also developed that the greatest trouble in the operation of this stoker results from the unfamiliarity of engine crews with it at the time of introduction. It takes considerable drilling to get a sufficient number of men on a division trained so that the stoker may be handled successfully in pool service. This difficulty, however, is a minor one, and naturally follows at the outset of the use of a device new in railroad service. As the stoker becomes more generally utilized this trouble will disappear.

Hanna Overfeed Stoker

This stoker, as far as developed, was briefly reviewed in the Proceedings of the American Railway Master Mechanics' Association for 1911, Vol. XLIV. It did not fully meet the requirements of the committee. As a coal-distributing means the Hanna stoker has successfully demonstrated its possibilities. It has been in continual service on engines of the consolidation, Pacific and Mallet types, giving a good account of itself, particularly when the engine crews took a personal interest in its operation. The manufacturers of the Hanna stoker are revising its design and construction so as to increase the scope of their apparatus to comply with the specifications as laid down by your committee.

The Barnum Underfeed Stoker

This stoker, as developed so far by the Chicago, Burlington & Quincy, employs screw conveyors located in troughs extending longitudinally just below the grates. The screw conveyors decrease in diameter from the rear of the fire-box to the front. Above the conveyors in each trough is a series of inclined plates, adjustable for height and inclination. The clearance between the conveyor and the bottom of the trough may also be adjusted to secure the best results. The conveyors are operated by a transverse worm shaft under the cab deck, which is rotated by two small steam engines secured onto the outside of the frames. A coal crusher on the latest type of stoker as applied to five 2-10-2 type engines recently built for the Chicago, Burlington & Quincy is also provided. This crusher is driven by a small steam engine located on the tender. It delivers coal to a belt conveyor, which transfers it to a transverse trough, from which it is discharged into the longitudinal feed troughs.

In addition to the five 2-10-2 type engines equipped above, the Barnum stoker has been in service on a switch engine of the Burlington road operating in Chicago, as well as a Prairie type engine operating in freight service. It is reported as having good results with both low-grade bituminous coal and lignite. It is further reported that the indications at this time for this stoker are that it is a practical machine, assisting in making steam readily and being free from failures and breakdowns.

DICKINSON OVERFEED STOKER

This stoker was tried out on the Erie. It employed the fundamental principle of coal distribution of the Hayden stoker further developed. It was equipped with a coal crusher and means for conveying coal, consisting of a screw conveyor transmitting the crushed coal to a bucket conveyor encased in a housing, which bucket conveyor in turn delivered the coal to the distributing mechanism. The apparatus was so arranged that it did not in any way encumber the fire-door. The entire machine was driven by two small steam engines, one operating the crusher, the other the conveying apparatus.

The conveying mechanism as well as the distributing device of this stoker was successful, but the coal crusher failed, due principally to its inadequacy. The engines, together with a few minor details, gave considerable trouble, although the complete combination gave a good showing when in proper repair. For it to be maintained in this condition, however, proved very expensive.

From the experience gained from the above stoker a second one was designed and built, seeking to avoid all the weaknesses of the first while incorporating all its good points. The modified stoker, as finally placed into operation, used only one engine of a special slow speed design, special form of boot, for the elevator carrying all the gearing to avoid encumbering the engine, an improved conveyor, a suitable coal crusher, and better coal distributing means. This stoker was finally placed into operation during the month of February last, applied to a consolidation freight engine. It soon developed that snow and moisture in the coal presented new difficulties by causing the fine coal to dry and cake in the elevator buckets, gradually filling them up, which so diminished the elevating capacity of the conveying mechanism that it clogged and stopped, finally resulting in a failure by breakage of the elevator chain. This trouble was probably due to wrongly designed buckets, since the bucket elevating system, as employed in the Street stoker, works without trouble. During the operation of the stoker, steam was satisfactorily maintained and the apparatus worked smoothly. It is now proposed to do away entirely with the bucket elevator scheme and substitute in its stead helical screw conveying means.

CONCLUSION

Generally speaking, in consideration of the foregoing review of the status of the mechanical stoker, the committee feels justified in concluding that decided progress has been made during the last year in the development of the mechanical stoker. While the perfection of the superheater and the brick arch have assisted in making possible a larger engine, it is considered, judging from these indications, that the advent of the perfected mechanical stoker will make possible a still larger engine.

The report is signed by T. Rumney (C. R. I. & P.), chairman; E. D. Nelson, C. E. Gossett (M. & St. L.), J. A. Carney (C. B. & Q.), T. O. Sechrist (C. N. O. & T.), S. K. Dickenson (L. S. & M. S.), and George Hodgins.

Safety Valves *

(1) The committee on safety valves herewith submits the following report: The suggestions given below apply to oil and coal-burning locomotives, whether using superheated or saturated steam. Safety valves suitable for the requirements of coal-burning locomotives should be ample for those burning oil, inasmuch as the enginemen have control of the fire of an oil-burning locomotive to a greater extent than on coal burners.

(2) *Formula for the Size of Valves*—In view of the variation in the various makes of safety valves as regards lift, any formula for the size of valve should take this item into consideration. No change should be made in the formula proposed by the committee of this association in 1910, except that the lift and diameter of the valve will be substituted for the area. The following formula is therefore suggested:

ASSUMING VALVES HAVE 45-DEGREE SEAT

D — the total of the actual diameters of the inner edge of the seats of valves required.

H — total heating surface of boiler in square feet. (Superheating surface not to be included.)

L — vertical lift of valve in inches.

P — absolute boiler pressure in pounds per square inch.

$$D = .036 \times \frac{H}{L \times P}.$$

EXAMPLE:

$$\frac{.036 \times 2878}{.1 \times 200} = 5.2$$ inches diameter, which would require two 3-inch valves.

(3) *Maximum Capacity of Safety Valves*—The only accurate method of determining the capacity of safety valves is by actual test in a testing plant, with safety valves fully equipped with springs, as in actual road service. In order that it should be positively known that safety valves will prevent undue raise in pressure under extreme conditions, they should be subjected to a road test.

(4) *Number and Size to be Applied*—Every locomotive should be equipped with not less than two, and not more than three safety valves, the size to be determined as per formula in paragraph two. Safety valves to be set as follows:

First. Boiler pressure.

Second. Two pounds in excess.

Third. Three pounds above second, or 5 pounds in excess of first.

(5) *Metal for Valves and Valve Seats*—No metal has yet been developed as entirely proof against erosion. Nickel seats and valves are desirable, and an improvement over other metal, but are expensive as to first cost and renewals, therefore the committee's recommendation is to continue the use of bronze alloys.

(6) *Stamping Lift on Valves*—Manufacturers should be required to stamp on the valve the lift in inches, as determined

* From a report presented at the Master Mechanics' Convention, Atlantic City, June, 1912, and published in the daily edition of the *Railway Age Gazette*, with whose permission the above abstract is reprinted.

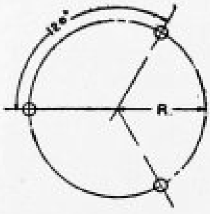
by actual test, with valve in working condition, and set for a blow-back of not to exceed 3 pounds. The committee recognizes the fundamental importance of valve lift. It therefore recommends that in design and manufacture valve lift receive proper consideration.

(7) *Estimating Steam Discharge*—Steam discharge from safety valves of given size can be estimated closely by the use of Napier's rule for flow of steam as follows:

Flow of steam per second, absolute pressure in pounds per square inch, multiplied by area in square inches of discharge opening divided by 70. Multiplied by 3,600 gives flow in pounds per hour.

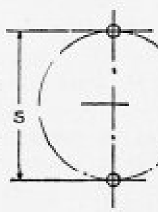
(8) *Location of Valves on Boilers*—The location of safety valves has much to do with the normal crest of the water in the boiler, therefore safety valves should be located at the highest point on the boiler, where clearance limits will permit, in vertical position, avoiding the use of piping, long nipples and ells between safety valves and boiler.

VALVE SIZE	SPACING S	RADIUS R
4½"	9"	5 3/16"
4"	8½"	4 7/8"
3½"	8"	4 5/8"
3"	7¼"	4 3/16"
2½"	6½"	3 3/4"



THREE VALVES

APPLICATIONS MADE AS DESCRIBED PERMIT USE OF WRENCH FITS RECOMENDED & MOVEMENT OF STANDARD WRENCH ONE SIXTH OF A TURN WITH A REASONABLE MARGIN



TWO VALVES

FIG. 1.—LOCATION OF SAFETY VALVES

(9) *Spacing in Dome*—Where safety valves are located on an independent dome they should be spaced as per Fig. 1. The opening from boiler into dome and the area between supporting ribs in dome should not be less than inlet area of valves. If this is not done the opening will momentarily reduce pressure, causing valve to flutter and hammer.

(10) *Hydrostatic and Other Tests*—The practice of screwing down the safety valve spring during a hydrostatic test of boiler should be discontinued. Valves with springs designed for certain pressures should not be subjected to extreme pressures. One safety valve should be removed and replaced with a special high-pressure valve, and the other valves should be removed and replaced with caps or plugs during test.

(11) *Standard Connections*—In order to make valves of different manufacture interchangeable, recommend standard thread and diameter of valves at connections as follows:

2½-inch valve	2½-inch U. S. S. pipe thread	8 threads to inch
3 -inch valve	3 -inch U. S. S. pipe thread	8 threads to inch
3½-inch valve	3½-inch U. S. S. pipe thread	8 threads to inch
4 -inch valve	4 -inch U. S. S. pipe thread	8 threads to inch
4½-inch valve	4½-inch U. S. S. pipe thread	8 threads to inch

Valves of above sizes to be made for U. S. S. wrench fit.

(12) *Inspection of Old Springs*—As it has been found that the condition of the safety valve springs greatly affects the discharge capacity of the valve, old springs should be tested as to their deflection under load before being used in required valves.

(13) *Repairs to Safety Valves*—Safety valves should be thoroughly overhauled and put in good condition whenever the locomotive is in shop for general repairs. Standard gages should be used in order that important dimensions may be maintained as originally designed. If this is not done it generally impairs the efficiency of the valves. The committee desire to thank the various manufacturers and members for the assistance rendered.

The report is signed by W. J. Tollerton (C. R. I. & P.), Chairman; I. B. Thomas (Penn.); W. D. Robb (G. T.) and E. C. Schmidt (University of Illinois).

A Preventative of Scale and Corrosion in Boilers

The question has occurred to me, why do so many of the brother engineers still persist in using strong chemicals to prevent internal corrosion and for the removal of scale from boilers? I have had a great deal of experience on land and at sea, and have found that chemicals that are strong enough to loosen and dissolve old scale will also attack the boiler itself. They will eat the flange packings in your steam line, destroy the piston rod packing and sometimes affect the rod itself. Now I had an experience some years ago which taught me a lesson. It taught me that there was a cheaper and more efficient way of removing scale and preventing same from forming than the use of strong chemicals.

We had just finished cleaning boilers after a lay-off of several weeks. I sent one of the firemen up over the tops of the boilers to get a small bag of graphite. He let the bag drop on top of one of the boilers, spilling about half of the contents of the bag, or about 20 to 25 pounds, down through the manhole and into the boiler. I thought at the time that it could not hurt anything, so I did not bother to clean it out, but forgot the incident and did not think of it again until I had it brought to my mind four or five months later, when we opened up the boilers for cleaning again.

I went through two of the boilers and found them in about the same shape as before. In between some of the tubes the scale had formed in a solid mass. On the shell and crown sheets there was from 1/16 to ⅛ inch hard scale. I put a couple of men in each boiler to scale and clean them, and I went on to the next boiler. You can imagine my surprise when I went into No. 3 boiler (on the same battery using water from the same source) to find it almost entirely free from scale. What had settled in the bottom was soft and could be crushed in your hand. Most of it could be washed out with a hose. I did not know what to make of conditions as I found them until I came out with a handful of sediment I had gathered up as I came out. Upon examining this I found it was mixed with graphite, and then I remembered the incident when the graphite was spilled in the boiler.

I have used graphite ever since as a preventative of internal corrosion and to prevent the forming of scale. The graphite I have used has left the boilers clean and does not impair the boiler, packing or engines. No more chemicals for mine. A boiler graphite that protects boilers, engines, etc., is good enough for me. W. V. FORD.

Norwich, Conn.

The most powerful locomotives yet built are the four recently completed for the Virginian railway by the American Locomotive Company. These engines have a maximum theoretical tractive effort of 138,000 pounds, simple, and 115,-000 pounds, compound. They will be used for pusher service on a 14-mile grade, the last 11½ miles of which is on a 2.07 grade. The engines exceed all previous designs in every particular except weight. The boilers are 100 inches outside diameter at the front end, 112 inches outside diameter at the largest ring. The total heating surface is 6,760 square feet, the superheating surface 1,310 square feet and the grate area 99.2 square feet. There are 344 2¼-inch tubes and 48 5½-inch superheating flues. The working pressure is 200 pounds per square inch.

The Boiler Maker

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Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Many of the large boiler shops that are now doing an extensive general boiler and sheet-metal business started years ago from a very small beginning. At that time the nature of the work done in a boiler shop was frequently classed by mechanics as "sledge-hammer engineering," since the equipment of the shop did not extend very far beyond a sledge hammer and a punch, and the product of the shop depended a good deal upon the manual skill of the workmen. Under such conditions the largest items in the cost of boiler making were labor and material. It did not require an exceptionally shrewd business man to estimate these costs; and since at that time competition was not so keen, an ample margin of profit could be allowed safely without paying very strict attention to the other expenses incurred by the shop itself, such as are commonly classed under the general heading of overhead charges. Consequently in those days a man who had become a skilled boiler maker and was thoroughly familiar with the mechanical end of the trade did not find it very difficult to take the initiative and establish a business of his own on a small scale with encouraging prospects of eventual success. In fact, that is the way in which some of the present successful boiler shops came into existence, and it is not unusual to find that the proprietors of these shops can relate some very interesting and instructive incidents regarding their rise from the "rivet-heating" days.

To-day, however, the business of boiler making has assumed a somewhat different aspect. There are not many localities in the country which offer such alluring opportunities for pioneers as formerly, and the rapid progress of engineering has brought to the boiler shop work of such magnitude and complexity that the somewhat scanty equipment of the old-time shop is totally incapable of handling the work. In fact, the modern boiler shop compares favorably with the big manufacturing plants in the other leading industries where the strictest attention has to be paid to the question of expenses and profits, and the successful management of a modern shop requires something more than guesswork in the estimation of overhead charges.

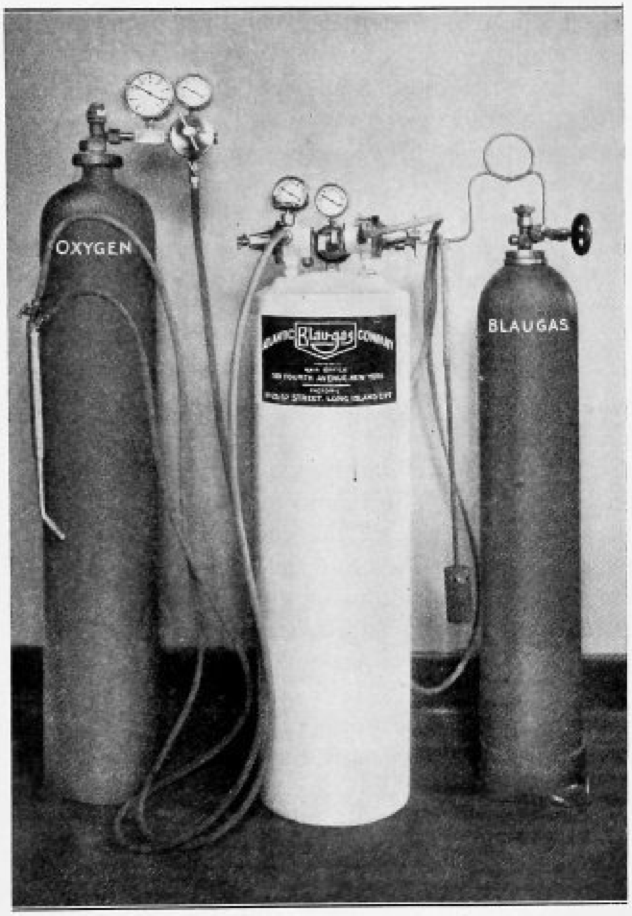
As shown by the letters published in this and recent issues, many otherwise competent boiler makers have been led astray on this subject, resulting in either serious losses or absolute failures. The suggestion that the question of properly estimating costs and profits be taken up by the Boiler Manufacturers' Association at its next meeting is an admirable one and should be given careful consideration by the members of that association. Meanwhile we hope that the manufacturers will not hesitate to send us some information covering their individual experiences along these lines. It may seem to some at first sight that an open discussion of this subject would involve the disclosure of important business secrets which rightfully belong only to those who have acquired the information by their own efforts and at their own expense. There is another side of the question, however, that should not be lost sight of, and that is that just so long as absurdly low estimates are submitted by a few manufacturers through their ignorance of the extent of overhead charges, as has frequently been the case, a widespread injustice has been done to the whole trade, and both the competent and incompetent manufacturers will share to some extent in the losses. To aid in correcting such injustices we would gladly welcome an open discussion of the subject through our columns.

Several articles that are published in this number take up the subject of boiler inspection. We have frequently called attention to the need of adequate inspection for all steam boilers in the United States and Canada. Even the few instances of flagrant neglect of proper inspection, as related by one of our contributors, should not be construed as exaggeration, or even as exceptional cases. Similar conditions exist not only in isolated country districts but also in crowded cities, where the danger is many times as great, and they will continue to exist until legal protection is obtained. Further than this, every effort should be made where boiler inspection laws are enacted to make the laws conform to an adopted standard, so that the requirements throughout the country will be uniform.

New Improved Engineering Specialties for Boiler-Making

The Oxy-Blaugas System

What is claimed to be a great advance in the progress of the metal welding and cutting industry has been brought about recently through the introduction of the Oxy-Blaugas system by the Atlantic Blaugas Company, of New York. While this system is operated in practically the same manner as the various oxy-acetylene systems, it has numerous advantages from a commercial point of view. Blaugas, which is used in combination with oxygen in the usual manner, is a compressed liquefied distillation gas produced from mineral oils. In the process of its manufacture the gas is reduced to 1/400 of its volume and all poisons and impurities are removed. One cubic foot of expanded Blaugas contains 1,800



British thermal units. Blaugas is especially well adapted for welding, cutting and brazing purposes on account of its exceptionally high heat value, its very narrow explosive range and its unparalleled transportability. The explosive range of Blaugas is only 4 percent, this being the narrowest range of any known commercial gas.

Blaugas is sold by the pound in steel cylinders, 43 inches high and 8 inches in diameter. Cylinders contain an average of 20 pounds of liquid Blaugas, which is sold at a standard price of 10 cents (5 pence) per pound. Each liquid pound expands into 12½ cubic feet of free gas, and from the above it may be figured that each cylinder contains approximately 250 cubic feet of gas at a price of only 4/5 cent (.4 pence) per cubic foot.

Taking into consideration the extremely low price of Blaugas, and the fact that amazingly large quantities are contained in small, easily-handled bottles, it may readily be seen that this system of metal welding and cutting is exceptionally economical.

A very important advantage of Oxy-Blaugas welding over the other autogenous welding systems is that the flame of the Oxy-Blaugas torch is much broader than that of the torches of the other systems, thereby insuring a greater and more uniformly heated area of the metal to be welded and preventing the high tension in the welded material. It is a well-established fact that, through the great differences of temperature produced in the material to be welded, a tension is created within the immediate area covered by the flame, and if the metal is subjected to tensile strength test it will frequently break directly beyond the weld, which disadvantage is greatly lessened with the Oxy-Blaugas system.

Besides being a most desirable medium for all welding, brazing and metal-cutting work, Blaugas is also used very largely for lighting, cooking and heating in homes, yachts, vessels, etc.

Faessler's Safety Sectional Expander with Quick-Acting Knock-Out

A new kink in the line of sectional boiler tube expanders has been brought out by the J. Faessler Manufacturing Company, Moberly, Mo. The essential new feature of this tool is the mandrel extractor. It consists of a sleeve fitting loosely over the mandrel and having an extended arm to receive blows, so that part of the force of each blow goes to the

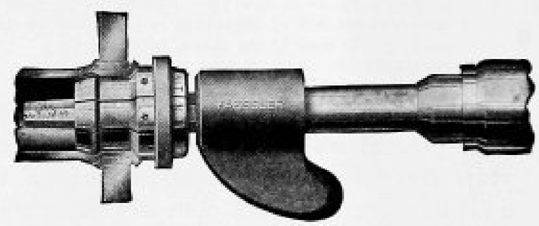


FIG. 1.—HAMMER PLACED TO EXPAND THE TUBE

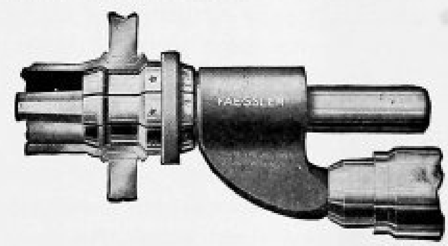


FIG. 2.—HAMMER APPLIED TO EXTRACT THE MANDREL

expander sections to free them from the mandrel, and also part of the force of the blows goes to the side of the mandrel to loosen it sidewise without marring it. Experienced boiler makers are thoroughly familiar with the frequency in which perfectly good mandrels have been battered up when knocking them out in the ordinary manner.

In this new tool the tube expansion is accomplished in the usual way and with a standard long taper mandrel. The extractor does not in any way interfere with expansion, and to save time it may remain upon the mandrel. To loosen or extract the mandrel after expansion is completed requires no flogging hammer where a pneumatic hammer is used. The operator merely shifts the point of application of the air hammer from the back end of the mandrel to the end of the lug on the extractor collar. The mandrel then releases itself almost instantaneously and backs out quickly.

Theoretically, each hammer impact forces the collar against the adjacent expander segment and moves it lengthwise before the segments are affected. The contact of collar and expander segments also affords a fulcrum over which the entire sleeve moves to impart to the mandrel a slight lateral impulse, which further tends to break contact with the expander segments.

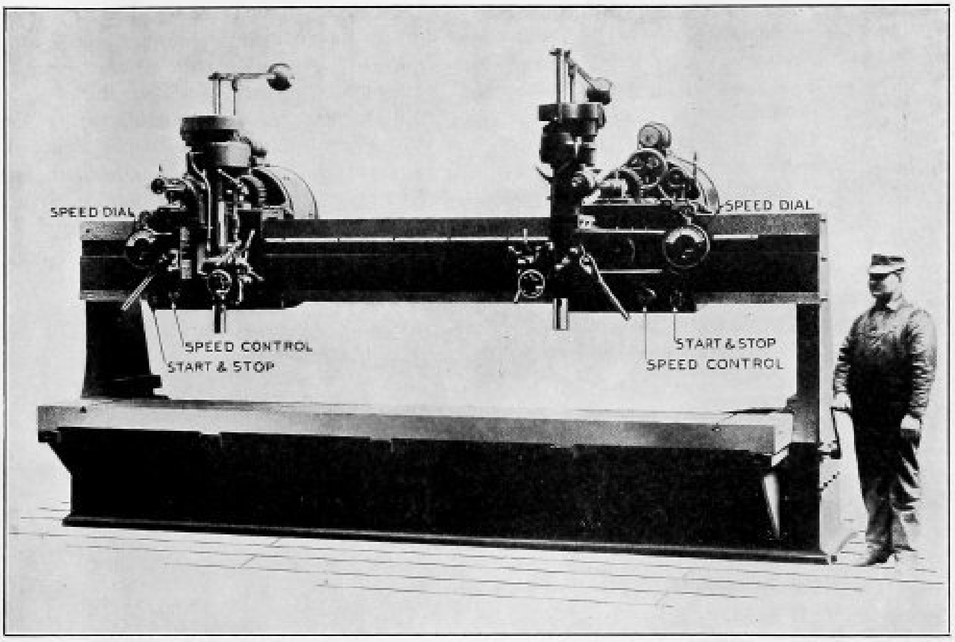
Where the mandrel is driven by a hand-hammer a few taps of the latter on the extractor lug are equally effective, the whole process being very simple.

A Heavy Mud Ring and Flue Sheet Drill

This machine, manufactured by the Foote-Burt Company, Cleveland, Ohio, was designed primarily to handle mud-rings and flue sheets in the most economical manner, but at the same time it was desirable to have a machine that was suitable for a general line of heavy work. The illustration shows that each of the two heads is an absolutely independent and self-contained unit, permitting the maximum flexibility in operation, allowing the correct feeds and speeds to be maintained for the particular size hole, being operated on under each spindle. The heads are provided with an in-and-out adjustment of 8 inches on the knee, which in combination with 24 inches of in-and-out adjustment of the table makes it possible to drill up a large layout at one setting. The saddles are worked along the rail by ratchet wrenches without the necessity of stopping the spindles. This adjustment is very easily made through suitable gear reduction.

Each spindle has an individual clutch drive, allowing the spindles to be started and stopped at will without the necessity of stopping the motor. Thus the motor can be adjusted for a certain speed, and need not be disturbed should it be necessary to stop the spindles for any cause whatever. Feed changes are obtained through a quick-change gear device, operated by a lever within easy reach of the operator. Power feed is provided with an automatic stop as well as the usual hand knock-off and clutch. There is a quick return by means of a spider hand wheel. When operating on mud-rings the brackets supporting the table are removed, special mud-ring chucks are placed on the table, which is run back between the housings. These brackets are doweled in position, allowing them to be readily removed and replaced.

The weight of the machine is 28,000 pounds, and the floor space required 15 feet 2½ inches by 4 feet. The motors are armature shifting type, having a speed range of 200-1,600 revolutions per minute, manufactured by the Reliance Electric & Engineering Company, Cleveland, Ohio. The shifting of the armature, which produces the speed changes, is accomplished by the small motor mounted on top of the large motor and connected to the shifting mechanism through sprockets and chain. To adjust the speed the operator simply presses the "fast" or "slow" button of the small speed control station conveniently located at the front of each head. Guesswork in setting the speed of the motor to give the best results for each job is eliminated by the Reliance speed dial, which is provided with two scales, the upper graduated to show cutting speeds in feet per minute and the lower the various sizes of drills.



FOOTE-BURT HEAVY MUD RING AND FLUE SHEET DRILL

Improved Non-Return Safety Boiler Stop Valve

The great importance of non-return boiler stop valves for use on a battery of boilers is universally acknowledged, and in some countries their installation is compulsory. It is evident that should a tube be blown out or a fitting ruptured in one of the boilers of a battery the steam from the other boilers would rush into the header and discharge into the disabled one. An ordinary stop valve would here be inadequate, as considerable time would necessarily be consumed in reaching and closing the valve, and a certain amount of danger must be anticipated. The non-return safety boiler stop valve shown herewith has been given very severe tests, and is in use in a large number of high-pressure power plants, in all cases, it is claimed, giving perfect satisfaction.

Fig. 1 shows a vertical section of the valve parallel to the pipe, and Fig. 2 a section at right angles to the pipe. When these valves are used, should an accident occur, such as the blowing out of a tube in the boiler or any rupture of the headers, shells, etc., permitting the steam to escape, the valve attached to that boiler will immediately close. This will prevent the escape of steam from the other boilers connected with it in battery, and the danger to life and property will be greatly lessened. The plant can be operated with the other boiler or boilers, without interference, thereby preventing the closing of same and the loss of time and money. This valve will prevent steam from being turned into a boiler which has been cut out for cleaning or repairs, as it cannot be opened by hand when pressure is on the header side. It can, however, be closed when desired. The valve can be connected in either horizontal or vertical position.

A unique arrangement of outside spring and lever mechanism has been provided for the purpose of effecting a slight counterbalancing effect to hold the valve open, this being necessary in order to counteract the influences within the valve or line which tend to actuate the disk with every slight fluctuation of pressure. These fluctuations, usually caused by the engine, are frequently met within steam lines, and unless some means, such as are shown in this construction, are applied for counteracting these pulsations, the disk will be kept in continual motion, and with the lack of lubrication within the dash-pot rapid wear will soon take place, causing a

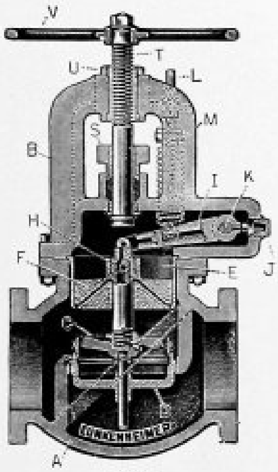


FIG. 1

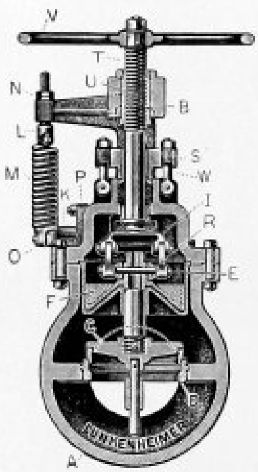


FIG. 2

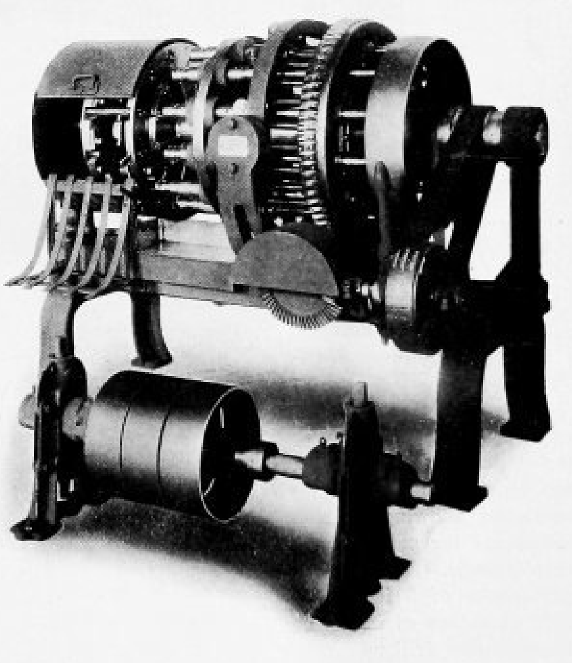
clearance between the piston and the dash-pot. As the amount of clearance increases the dash-pot becomes less effective and a chattering soon results, causing great damage to the internal parts of the valve. Where the fluctuations of pressure do not exist, and the flow of steam is steady, the use of the exterior spring and lever mechanism is not necessary. Hence the valves are regularly furnished without tension on the spring, and the dash-pot arrangement can here be depended upon to cushion the movement of the disk.

Should a pulsating condition develop, which can easily be detected by observing the movement of the spindle *L*, the regulating nuts *N* can be adjusted, gradually placing the spring under tension until the rapid movement of the spindle *L* is stopped. This adjustment of the nuts tends to lift the disk from off its seat as it places the spring under tension, causing it to pull upon the lever *O*. This lever is keyed to the shaft *K*, which shaft enters the valve through the stuffing-box *P*. Attached to the shaft *O* is the forked arm *I*, to which are pivoted the links *R*, which in turn are loosely connected to the piston *F*. When the spring is under tension the disk is raised from its seat and cannot close until the steam pressure above the disk exceeds that under it. This difference in pressure, which is governed by the tension of the spring, is never more than 5 pounds.

When the valve is properly set to overcome the tendency of pulsation, the disk remains practically in equilibrium until there is a reduction in pressure on the inlet side, when it will instantly close. Attention is called to the large bearing surface of the piston within the dash-pot. All parts of the valve subjected to wear are renewable, and this includes the disk and seat ring, though the seating faces of the disk and seat ring can be reground a number of times before it is necessary to renew these parts. The stuffing-box, through which the stem *T* travels, is of large size and entirely exposed to the cooling effects of the air. It can be packed under pressure when the stem is raised to its limit, as a shoulder on the bottom of the stem forms a seat against the bronze bushing in the bottom of the stuffing-box. The stem *T* operates in the bronze hub *U* in the top of the yoke and bronze bushings in the gland and stuffing-box, thereby preventing corrosion and insuring easy operation. These valves are made by The Lunkenheimer Company, of Cincinnati, Ohio, in five different combinations of materials in order to suit the requirements of various conditions of superheat and high-pressure, and also to meet the specifications of engineers who may differ as to what is best suited to the purpose.

Multiple Spindle Stay-Bolt Semi-Automatic Drilling Machine

A twelve-spindle, semi-automatic drilling machine, which will drill any depth hole from 0 to 2⅞ inches, using 7/32-inch drills, or, when otherwise ordered, using any size drill from 3/16 inch to ¼ inch, is manufactured by the Richmond Staybolt Drilling Machine Manufacturing Company, Richmond, Va. There are twelve drill spindles and the same number of receptacles for receiving and holding stay-bolts. The drill spindles are of 1-inch machine steel, and each carries an Oneida National Drill Chuck No. 0, that will take from 0 inch to ⅜ inch. Each drill spindle is driven by an independent



machine steel gear, 3 inches diameter by 1¼-inch face. These gears are enclosed inside of the large spiral gear, and are fully protected from dirt and chips, and are driven by one 12-inch cast iron gear, with 1¼-inch face. This gear is driven by a 20-inch by 4-inch face belt pulley from a countershaft. The main body of this machine is cylindrical, drill heads and bolt receptacles being rigidly connected on a dead line, and revolving slowly on the main shaft, which is stationary, and firmly secured to main supporting arms by keys and set screws. The drill heads are revolved slowly by being connected directly to a large spiral gear, which is driven by a spiral worm, which again is driven by bevel gears from a small pulley from the main pulley, there being a clutch arranged on the bevel gear shaft to stop the motion of drill heads without stopping the drills.

Communications of Interest from Practical Boiler Makers

Lengthening Boiler Tubes

We are usually told that when our hair gets gray our heads are full of knowledge, and it should be so, but I have run across some gray-haired fools in my day. In the story I am about to give you this gray-head idea gets a "knock-out blow." I might as well say that my hair is gray.

There were two tramp steamers doing work in the West Indian trade, and I was chief of one of them. The chief of the other got sick and cleared out for home, and just at that time the owners got a contract for two years on a very good run. My ship was not old, but the other was, and I was given the job of looking her over to see what had to be done to keep her going.

When I went on board I found that the old chief had left things in a very good way; that is, he had a memorandum of all that was wanted to make repairs with, and had even started some. Among other things he had ordered new tubes for the two boilers, and they had arrived. I soon got all the material needed for my work and we laid up to put the work through.

I had a very good lot of help; none of your "let-those-other-fellows-do-it" kind, but hard workers, and the captain was a man who made you toe the mark; but he always had a good word for a worker, so we liked him as well as one can like a captain.

Our cook was a Yankee lad, only about 21 years of age; a boy whom we all liked, and he could cook, and was clean as could be in his work; he always had something cool for us to drink during the day, and he did not forget the crew.

We got all the tubes out of the boiler, and it was no joke, either, and I was just about to turn in for a snooze, when up came the "First" in a great state. He shouted as soon as he caught sight of me: "Mon, alive, the d—— tubes are three-eighths too short!" And true enough I found he was right. Well, the captain had something to say not to my liking, and we had made up our minds to wire for more tubes, when in came the boy cook. We were in the captain's cabin, so you can perhaps understand how he looked at the boy. The boy did not "stand on the order of his saying," but said at once: "Say, captain, I can make those tubes all right." The captain remarked, "You might, my boy, if they were macaroni; will you be so good as to return to your galley?" only he did not use that exact lot of words, and perhaps you would not print just what he did say. But the boy stood his ground, and said: "I know what I am talking about. I worked six months for a blacksmith once, and I know the trick. But I won't turn it unless I get a month's extra pay." Well, strange to say, without bloodshed, we gave the boy a chance, with the proviso that he was to get a rope's end if he did not make good.

He came below, and insisted on having the fire-room to himself. He got out a hand-forge which we had, it was quite a large one for a ship, and we all retired to the deck to await results, and I noticed the captain spying about for that rope's end, and when the boy came on deck in about half an hour the captain was kinder hefting the rope in his right hand. We had one of the tubes on a bit of old canvas spread out on the deck, and the boy laid his tube down alongside of it, and true enough it was almost half an inch longer than the original; not a hammer mark could I see on the tube, all that could be seen was that it had been heated about the middle.

Two more tubes were "treated," and then the boy turned to and worked like a major, and by next day evening the lot were done.

It was quite a while before the boy showed me the trick, and I am sure I would never have believed it could be done had I not had the experience I have given, and besides I have tried it several times since. Here is how it is done: The tube is heated up to a red heat about its middle; it is then bent about 40 degrees, then bent straight again; shoved onto a steel bar and tapped true with a wooden mall, and that is all there is to it. In my first case the tubes were 2½ inches diameter and a little heavier than 10-gage. I have stretched tubes almost twice as much as the boy did his lot by heating twice. Of course, the tube is a little thinner at the "stretch," but not much, and it is in a place where an inspector can't get fussy about it. Coupling.

Square or Cylindrical Tanks?

I note Mr. Haas' communication in your July issue regarding the construction of a 3,000-gallon tank made for a testing concern in London, England, and I must agree with Mr. Haas that the substituting of a cylindrical for a rectangular tank in this case was the proper solution of the problem.

Mr. Haas states the tank was square, and was made of 3/32-inch plate, and inasmuch as the test was made in England we must assume that Imperial measurement was used.

If the tank was made in the form of a square (or cube) it must have measured approximately 95 inches each way—height, width and length—to contain 3,000 gallons; and without going into further details it would appear that 3/32-inch plate (equal to No. 13 U. S. gage) for a tank of the capacity stated would be ridiculously light, and, to prevent it from entirely collapsing when filled its full height, must have required a network of braces. A better plan would have been to have built a wood case around the tank.

A rectangular tank could no doubt be made to withstand an internal pressure without practically any bulge, provided, of course, that material of heavier gage is used and properly distributed tie bars are provided.

The demand for rectangular tanks is increasing each year, from the fact that they require less space for the same capacity, and also from the fact that floor space is becoming more valuable. Rectangular tanks are much preferred by varnish makers and manufacturers of similar articles, who are obliged to provide large storage capacity and with whom floor space is an important item. The first cost of this type of tank is, of course, considerably more than a cylindrical tank, but when floor space is taken into consideration it will be found that the rectangular is the cheapest in the end.

For example: A vertical tank 60 inches diameter and 96 inches high will contain 1,175 United States gallons. If the top edge of the tank is reinforced with an angle-ring on the outside, say 2½ inches wide, by reason of having a bolted cover plate or other loose-fitting cover, and the tanks are placed in a battery, each tank would take up an area equal to 65 inches square. A rectangular tank occupying the same area would have a capacity of 1,712 United States gallons, an increase of storage capacity of nearly 50 percent over the cylindrical tank.

Is this not an excellent argument in favor of the rectangular tank? Tank manufacturers should give the proper gage and bracing of rectangular tanks careful and serious consideration, as the demand is increasing, and they will be called upon to construct a tank that can be guaranteed to hold up without bulging or swelling. G. A. S.

Fort Wayne, Ind.

Concerning the A. B. M. A.

Mr. W. C. Connelly's suggestions in the July issue of THE BOILER MAKER should cease to be such and become realities with all possible speed. First, there is every reason why tank builders and other heavy plate workers should join the American Boiler Makers' Association; their lines of business are closely connected with boiler work, and the more they meet with boiler makers and the more boiler makers meet with them, the sooner good will result from the interchange of ideas which both have. If the rules and by-laws of the association do not now permit these metal workers to become members, by all means have them changed so they can join, and if no such action is necessary let steps be taken to get them in at once. Mr. Connelly is absolutely right, every boiler maker should become a member of the association and go to the meetings; no one can do so and not come away richer in knowledge of his craft and with a better and more friendly knowledge of his fellow craftsmen.

The suggestion of a "cost" or profit day is most happy, and no better practical idea has originated from the organization. All who are in the boiler business, or in fact, any business, are after profits, and it is evident from what Mr. Connelly and "Progressive" say that many are entirely without proper knowledge as to the cost of their work or how to find out what it is; but I must say that this applies with equal force to many classes of manufacturers.

The illustrations given by Mr. Connelly bring to my mind the story of the old lady up in New England where they used to have "Training Day"; that is, a day when all able-bodied men had to do military duty. It used to fill the town with men, so the old lady made a lot of crullers, or doughnuts, to sell to them, and she told a friend, with great glee, that she had made $3. "But," asked her friend, "how much did the flour and sugar and fat cost you to make the crullers with?" "Oh, nothing at all," said the old lady, "I had all that in the house!"

As a consulting engineer I have to go into this question of "overhead," "burden" or "constant factor," or whatever you wish to call it, and I have found some difficulty in convincing some people that it even exists, especially where the property is owned and not leased or rented, as the old lady's idea seemed to prevail, that as the land and building were owned they had not cost anything; yet it did not please at all when I suggested that they were worthless. This "overhead," or as I prefer to call it, "constant factor," must, of course, vary with different boiler works, but it must, in all cases, be made up of exactly the same charges. I have had some curious experiences in considering this very important subject, as the following will show:

A shop, which was making money—on its books—could not always meet its pay roll, and the unpaid bills were rolling up very near the danger mark. I was called in and found a well-kept account of labor and material, salaries and general payments made, but not a cent was charged for interest on investment, money invested, depreciation, insurance or bad debts. An "overhead" of 22 percent was allowed on all shop cost. On looking into the matter I found the charge should have been 66 percent, and this was proved by the amount run behind during the past three years.

The owner could not believe it; as a friend in a town, not far away, in the same business was making money with a "constant factor" of about 20 percent. I went to see the friend; and sure enough he had a good bank balance and was paying his bills on time. This was a "poser," but after looking over his books, which he was good enough to let me do, the reason was made clear. He owned several houses and lots, all of which were paying very well, but the income from them was dumped into the bank, and as it amounted to far more than the losses made by the shop work the owner thought he had been making money in his boiler shop. His "constant factor" proved to be a little over 66 percent.

The fact of the absurd differences in boiler bids is easily accounted for by these examples. To figure not to lose on a job an absolute knowledge of the total cost of the business must not be guessed at but be positively known. To drive a rivet may take exactly the same time and the amount of wages paid may be exactly the same in two shops, the actual cost in one may be, and often is, twice as much as in the other, because of the high overhead charges. It is not the labor and material cost that people get astray on, but the "overhead cost"—the deadly expense which is not easily seen, yet so severely felt sooner or later.

There is a great aversion on the part of most business concerns to face the fact of what it costs to run them, and this aversion will be found in a meeting of boiler makers who get together to discuss the subject. It will be argued that if others know what it costs to run a business they have a much better chance to figure to win; but to win a loss, that is, to get a job which is sure to make a loss, is not business.

It will be answered that it is better to take a job at a loss and keep going than it is to shut down and have the men scatter. Perhaps it is, if you want to fool the bank, for a little time, and your associates, or if you want to do the philanthropic act or sell out on "boosted" conditions, but to make real money, no!

Let us look into this "constant factor" business. It is constant in fact, as most of it "works while you sleep." What is it made up of? How should it be divided and kept watch of?

Here are some of the items, perhaps not quite all for all businesses, but for most:

GROUP A

Interest on investment; interest on borrowed money; taxes, rent, insurance; depreciation on tools and building.

GROUP B

Salaries of all non-producers; stationery, postage, expressage, telegraph, telephone; traveling expenses, legal services, bad debts; concessions on payments, commissions; light, heat; losses by interest on delayed payments; social (tickets and subscriptions, etc.).

GROUP C

Fuel, power, repairs; oil and waste; small tools; drawings and prints; supplies.

In Group A the items cannot be reduced except on the borrowed money item, and that change is, to my mind, really no change at all, as if you borrow $1,000 and put it in your business it is something on which you will have to pay interest, just as much as if the bank held the loan, as you will still have to make your loan percentage, or you will not be fair to yourself and associates. You might just as well say that you are out of debt if you borrow $10,000 to pay your outstanding debts when you get the receipted bills.

I firmly believe that a very small proportion of boiler shops really know just what it costs them to do a job, and that in many cases it is a matter of pride, and not business, that keeps them going at all. It is time that the matter of costs be taken up by the association, and it will result in good all around. Good men should be brought to the meeting who know the subject, and a full campaign of instruction entered into, with a view to showing the very low bidder the danger to himself and the injustice he is doing to others by not knowing what it costs him to do work.

New London, Conn. W. D. FORBES, M. E.,
Consulting Engineer.

Development of 60-Degree Frustum of a Cone in Three Pieces with the Aid of Trigonometry

While I have seen various angles worked out and illustrated in THE BOILER MAKER, showing the use of trigonometry, I have not as yet seen trigonometry actually applied to laying out, or rather to the layout of any particular piece, or course. It appears that the average layer-out seems to even dread to hear the word trigonometry. There are a vast majority of layer-outs who seem to get along without the knowledge of it, but I cannot state that they do so comfortably. Trigonometry is not only essential in laying out but is an actual necessity, and without its use in various layouts it would prove to be a very difficult task for the layer-out to proceed with his work properly.

The layout which I have selected can very easily be made

$$\frac{50 \times 46}{23} = 100 \text{ inches} = R\ 1$$

To find the developed angle and make the course in three plates we have the formula:

$$\frac{180\ D}{R\ 1} = \frac{180 \times 100}{100} = 180 \text{ degrees,}$$

providing that the course were to be made with one plate, but as the course is to be made of three plates we have $180 \div 3 = 60$ degrees, the whole angle of each of the three plates. Now, by dividing 60 degrees by 2 we have the proper angle with which we are to work, namely:

$$\frac{60}{2} = 30 \text{ degrees.}$$

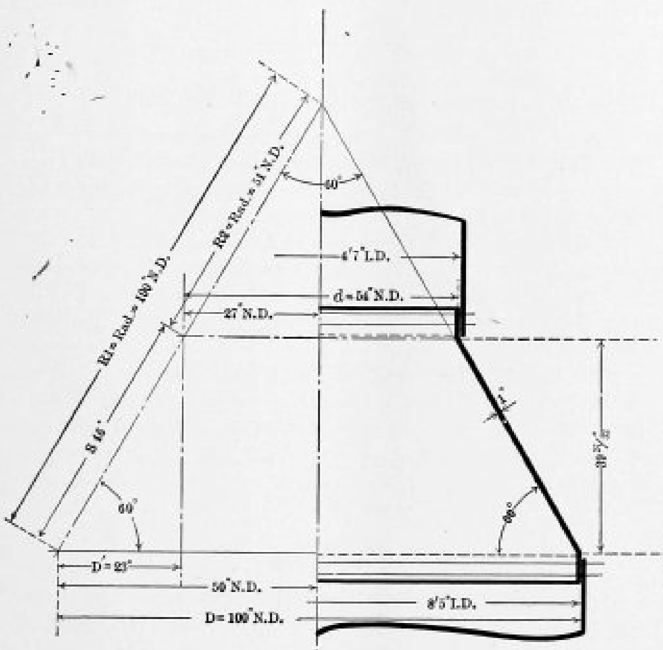


FIG. 1

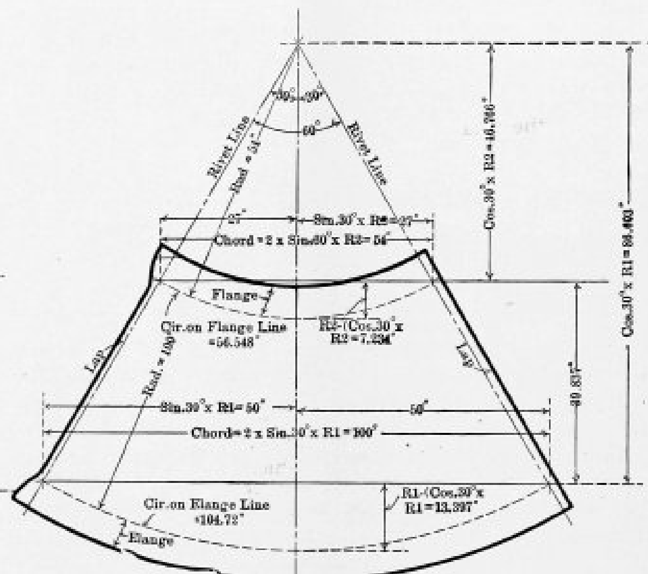


FIG. 2

without the application of trigonometry on account of the small dimensions of the piece, but there are many instances where the dimensions are very much larger, and then with the aid of trigonometry one can very easily check his layouts and see if they are correct.

In Fig. 1 we have on the right side of the center line a sectional view of a frustum of a cone, the small end of which fits into a shell 4 feet 7 inches inside diameter, and the large end into a shell 8 feet 5 inches inside diameter, the height of the frustum being 39 27/32 inches at the flanges.

To proceed with the layout it is best to draw a sketch as is shown on the left of the center line in Fig. 1. These lines must all be the neutral lines. (*N. D.*)

The next step is to find the difference between the larger diameter and the smaller diameter D'.

$$D' = \frac{D - d}{2} = \frac{100 - 54}{2} = 23 \text{ inches.}$$

Now to get the larger radius R 1 we have the proportion:

$I : S :: R : R\ 1$ or as
23 : 46 : : 50 : 100

* These functions can be had from almost any mechanic's pocketbook.

Sine* for 30 degrees = 0.5000.
Cosine* for 30 degrees = 0.86603.

Now, before going any further, it will be best to obtain the slant height of the course. This is simply obtaining the hypotenuse of the triangle where 23 inches is the side adjacent or base, and 39.837 inches is the side opposite, or the perpendicular.

This height, $S = 46$ inches, subtracted from the larger radius, gives us $100 - 46 = 54$ inches, or R 2.

The lengths of one-half the chord of our layout on the large and small ends are found very easily. For the large end we have:

Sine of 30 degrees $\times R$ 1, or
$0.5000 \times 100 = 50$ inches,
and $50 \times 2 = 100$ inches.

For the small end we have:

Sine of 30 degrees $\times R$ 2, or
$0.5000 \times 54 = 27$ inches,
and $27 \times 2 = 54$ inches.

Now to obtain the distance between the chord at the small end and the point of intersection of our angle, we have:

Cosine of 30 degrees $\times$ R 2, or
0.86603 $\times$ 54 = 46.766 inches.

For the large end we have:

Cosine 30 degrees $\times$ R 1, or
0.86603 $\times$ 100 = 86.603 inches.

Now if the slant height S = 46 inches were given on the drawing instead of 39.837 inches, the straight height would be obtained by subtracting the difference between 86.603 inches and 46.766 inches.

The camber or rise in the center of the layout is obtained by the following:

R 1 — (cosine 30 degrees $\times$ R 1), or
100 — 86.603 = 13.397 inches for the large end.

For the small end we have:

R 2 — (cosine 30 degrees $\times$ R 2), or
54 — 46.766 = 7.234 inches.

The length of the entire course at the small end on the flange line is

54 $\times$ 3.1416 = 169.6464 inches,

and as we have three plates to the course, the distance on one plate will be

$$\frac{169.6464}{3} = 56.548 \text{ inches.}$$

For the large end the total circumference is

100 $\times$ 3.1416 = 314.16 inches, and

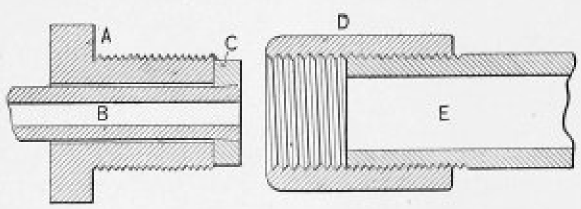
$$\frac{314.16}{3} = 104.72 \text{ inches for one plate.}$$

The apprentice should work this problem out by the use of radial lines and afterwards figure it out. By so doing he will soon realize the advantage of figuring out a layout where it is impossible to use the trams on account of the large radius.

In the future I shall demonstrate the advantage of trigonometry in the layouts of various elbows, which I know will be appreciated by quite a number of readers of THE BOILER MAKER. J. F. HAVLAK.

An Improved Test Union

The usual method of attachment of the soft copper tubing from test pump to job is by means of a regular hexagon union having the female thread inside the hexagon nut, the complementary portion being the male thread brazed to the remainder of the pipe. Both portions being brass and needing



UNION FOR TESTING

two spanners to tighten, sometimes give trouble and frequently leak at high pressures, the amount of thread provided being short.

The sketch shows a design successfully used for the purpose and for quite high pressures, 1,000 to 2,000 pounds per square inch, the usual position of the exterior thread being carried on the collar portion of the pipe. It is used with a wrought iron barrel screwed into the boiler front, and has over a term of years given every satisfaction.

For the testing of jobs made of barrel and tested to high pressures it is ideal, a simple union being screwed hard home onto the taper of the screw at the terminal, the screw bushing A making an effective joint between collar face and the faced end of the barrel inside the union.

The pipe B is of copper, with collar C soundly brazed on, the bushing A being made of cast iron with hexagon flange as shown. The corresponding portion of the barrel is E, with the faced end and D union.

It is a cheaper construction; only one braze is needed, while the bushings are quite a cheap job, and being made of cast iron suffer less from rough usage than the usual brass made of an ordinary coupling.

A joint washer can be used if desired, but the pressure exerted by the bushing is sufficient for metal to metal joints. In this case the end of pipe should be coned and the collar made to correspond. A. L. HAAS.

London, England.

Figuring Costs and Profits

I have read with much interest the communication from Mr. Connelly regarding the boiler maker who added 10 percent for profit after figuring out the cost of material and labor. No wonder he had financial troubles.

A few years ago I happened to be intimately acquainted with a large machine tool concern in New England that followed the plan of adding to the cost of material and labor 65 percent for overhead charges and then 20 percent for manufacturer's profit.

This concern was apparently well managed; for it has always been regarded as a successful concern, and is doing a larger business each year. Yet with this basis of figuring profits the concern has scarcely paid more than 6 percent dividends. X. Y. Z.

Personal

A. D. ROGERS has been appointed Federal district boiler inspector at Kansas City, Mo., vice T. W. Anderson, deceased.

R. W. ROGERS has been appointed practical and technical instructor of apprentices at the Erie shops, Port Jervis, N. Y. Mr. Rogers was formerly assistant engineer of tests at the Erie shops, Meadville, Pa.

F. A. TEBEAU has recently resigned as layerout for the Kingsford Foundry & Machine Works, Oswego, N. Y., to accept the position of foreman boiler maker with the P. F. Woods Boiler Works, New Bedford, Mass.

M. E. SHERLAND, foreman boiler maker of the Missouri-Pacific-Iron Mountain Railroad at McGehee, Ark., has been given supervision over all pumping station boilers on the Valley division, comprisng the McGehee, Monroe, Alexandria and Lake Charles districts. This work was formerly attended to by the way department, with Little Rock, Ark., as headquarters.

JOHN E. TRUCKSES, master boiler maker at the navy yard, Boston, Mass., has recently resigned to accept the position of general foreman boiler maker of the New York Shipbuilding Company, Camden, N. J. This change will now enable Mr. Truckses to display his wide knowledge of the art of boiler making without being hampered with yards of "red tape," as is inevitably the case in a Government yard. The New York Shipbuilding Company has secured a "live man" to head its boiler department, and both the company and Mr. Truckses are to be congratulated upon a connection which is of such material advantage.

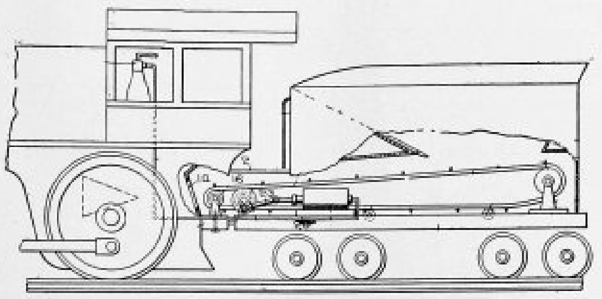
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,018,421. AUTOMATIC COAL-FEEDING MECHANISM FOR LOCOMOTIVE AND OTHER FIRE-BOXES. FRANK A. JACKSON, OF GARLAND, ARK., ASSIGNOR OF ONE-HALF TO INVENTORS' UNION COMPANY.

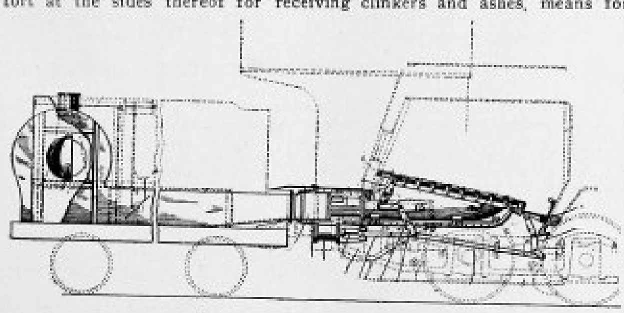
Claim 2.—The combination with a coal car having sloping guide bottom portions and a coal leveling portion, the edges of one of the sloping botom portions and of the coal leveling portion meeting and coal breaking teeth secured upon the sloping bottom portion at the junction thereof with the coal leveling portion; of an endless feeding belt working within the bottom of the coal car beneath the sloping and leveling bottom portions thereof, teeth on the outer surface of the endless belt for



moving the coal into engagement with the teeth on the sloping bottom portion, means for supporting the belt to operate and carry the coal in a horizontal direction to be fed to the fire box of a locomotive connected to the coal car, the endless feeder supporting means being mounted to allow the engine and coal car to turn without affecting the operation of the endless feeder, and means for operating and controlling the endless feeder. Two claims.

1,018,976. AUTOMATIC STOKER. WILLIAM J. KENNY AND HENRY P. GROHN, OF CHICAGO, ILL., ASSIGNORS TO THE UNDERFEED STOKER COMPANY OF AMERICA, OF CHICAGO, ILL., A CORPORATION OF NEW JERSEY.

Claim 1.—In combination in a stoker, a retort for receiving the fuel to be consumed, reciprocable plates arranged longitudinally of the retort at the sides thereof for receiving clinkers and ashes, means for



reciprocating said plates in the longitudinal direction to move the clinkers and ashes toward one end of the retort, and means operating during the backward motion of the reciprocable plates to remove the clinkers and ashes at said end of the retort. Sixteen claims.

1,018,967. FURNACE. NATHANIEL FROST, OF BLOOMINGTON, ILL.

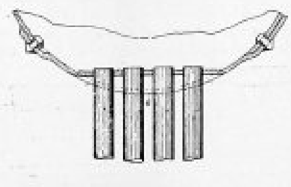
Claim.—A furnace having a fire-box and having its rear portion divided to form passages, a one-piece hollow back breeching communicating at its lower portion with said passages and bifurcated to form upwardly extending spaced branches and a portion between the lower ends of the branches, constituting a saddle and having an opening communicating with the interior of the breeching, a hollow front breeching, conduits extending from said branches of said back breeching to the side portions of the front breeching, a smoke pipe normally open to the front breeching and extending rearwardly therefrom between the said branches of the back breeching, said smoke pipe having an opening coinciding with the said saddle opening, and a damper controlling direct communication of the back breeching and said smoke pipe. One claim.

1,019,082. AUTOMATIC STOKER. GEORGE W. PHILLIP, OF CANTON, N. C., ASSIGNOR TO MURPHY IRON WORKS, OF DETROIT, MICH., A CORPORATION OF MICHIGAN.

Claim 1.—In an automatic stoker, the combination of a coking plate, an air flue extending beneath said plate longitudinally thereof, a magazine extending the length of said plate with its discharge throat above said plate and comprising an arch plate forming one side of the magazine provided with a seat for an arch and a member forming one end of the magazine having a chamber open at one side beneath the arch seat at the end of the coking plate and into which chamber the air flue opens, a chambered member interlocked with said member and having a vertical wall forming a closure for said opening at the end of the coking plate, and means for holding the parts interlocked. Three claims.

1,021,204. MEANS FOR ATTACHING WATER-TUBES TO WATER-TUBE BOILER AND OTHER DRUMS. WILLIAM D. McNAULL, OF TOLEDO, OHIO.

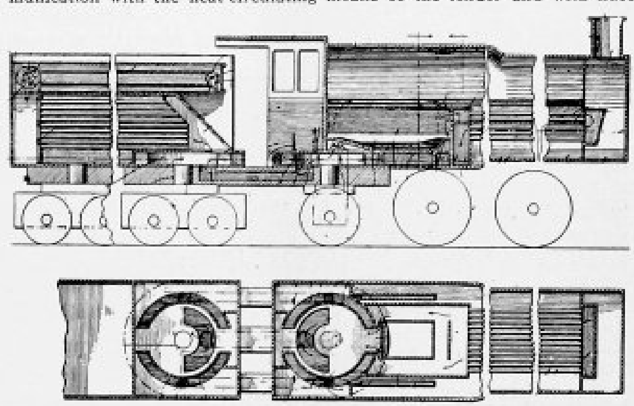
Claim 2.—In a device, a drum having, at intervals along one side, transverse flattened portions in which are groups of holes, said drum



being outwardly and transversely crimped between the neighboring flattened portions in substantially an arc of the transverse outline of the drum, and tubes connected with said holes. Two claims.

1,021,455. LOCOMOTIVE. THOMAS RUSSELL DAWSON, OF BARNESBORO, PA.

Claim 2.—A locomotive comprising an engine provided with heat-circulating and discharging flues, a tender provided with heat-circulating means, means pivotally connected to the engine and tender and provided with a flue for placing the circulating flues of the engine in communication with the heat-circulating means of the tender and with flues



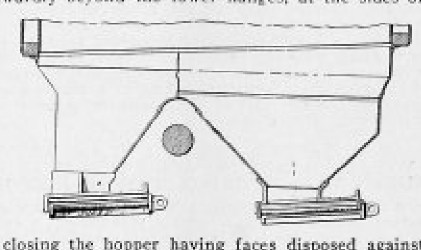
for conducting the heat from the tender to the discharging flues of the engine, a damper for preventing heat passing through the circulating means of the tender, and dampers for placing the circulating flues of the engine in direct communication with the discharging flues. Nine claims.

1,021,556. GRATE. JOHN C. QUINN, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE ENGINEER COMPANY, A CORPORATION OF NEW YORK.

Claim 2.—A grate consisting of a series of grate bars arranged longitudinally side by side and each having a groove extending longitudinally to the top of the face thereof and side horns at the upper part thereof and extending laterally from the sides of the bar, the upper faces of such horns having grooves or channels formed therein open to air spaces between the horns on the opposite side of the bar and communicating with said longitudinal groove in the top face of the bar, the bars being so arranged and located that the extremities of the horns on opposite sides of each of two adjacent bars extend toward the spaces between the horns of the other bars. Three claims.

1,021,668. LOCOMOTIVE ASH-PAN. JAMES F. DUNN, OF SALT LAKE CITY, UTAH.

Claim 1.—In a locomotive ash pan a hopper, oppositely disposed guide members at the sides of the hopper each having two outwardly extending parallel flanges, one disposed over the other with the upper flanges extending outwardly beyond the lower flanges, at the sides of the device,



a door for closing the hopper having faces disposed against the bottom of the lower flanges, and side members disposed at the outer sides of the lower flanges, and covered by the upper flanges, and inwardly extending bearing flanges on the side members disposed for traveling between the flanges on the guide members. Two claims.

1,020,642. FEED-WATER REGULATOR. MARTIN ELKOFER, OF LEIPZIG, GERMANY.

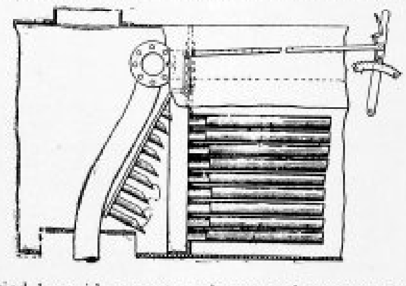
Claim 1.—In a feed-water regulator the combination of a feed-conduit, a feed-valve, float mechanism controlling said feed-valve, said float mechanism comprising a float chamber having a discharge orifice leading to said feed-conduit, and a second valve operative in conjunction with the feed-valve so that said second valve closes said discharge-orifice when the feed valve is opened. Three claims.

1,020,635. TUBE-CLEANER CONNECTION FOR BOILERS. HUGH CASSIDY, OF BROOKLYN, N. Y.

Claim 1.—A pair of boilers having tubes in combination with a fixed pipe, an extension-pipe, a swivel coupling connecting said extension-pipe with said fixed pipe, said tubular extension pipe having swivel couplings adapted to permit extending the members thereof and a nozzle carried by said extension-pipe and adapted to be applied to the said boiler-tubes. Seven claims.

1,023,949. DRAFT-REGULATOR FOR FIRE-TUBE BOILERS. CHARNOCK H. McCALL, OF ATLANTA, GA.

Claim 1.—The combination with a fire tube boiler having a tube sheet, of a support pivotally mounted adjacent said tube sheet, and a plurality



of plugs carried by said support, and arranged to enter the ends of the tubes as the support is swung on its pivot, the length of said plugs increasing in proportion to their distance from the pivot. Three claims.

1,024,641. FEED-WATER HEATER. JOHN McQUAT MACKIE, OF MONTREAL, QUEBEC, CANADA.

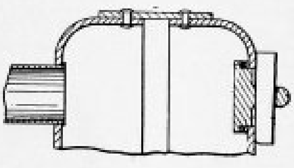
Claim 2.—In a feed-water heater, the combination of an outer casing constituting a steam heating chamber, and a water-carrying member within the heating chamber removable bodily therefrom without disturbing the steam connections; the casing being formed of a flanged cylindrical portion, provided with inlet and outlet openings for steam, and flanged end caps, identical in form and each having an opening therein, bolted to the cylindrical portion and perforated for the passage of a water pipe therethrough; the water-carrying member being composed of two perforated disk plates or sheets each of sufficiently smaller diameter than the interior of the casing to leave a free space between its edge and such casing, a plurality of water tubes extending between said disks and secured in the perforations thereof, and two identically formed concave headers each of which has an opening therein and is bolted to one of the said disk plates; and water inlet and outlet pipes passing slidably through the openings in the end caps of the casing and tapped into the openings in the headers of the water-carrying member. Two claims.

1,022,757. SMOKE-BOX DOOR. DAVID SAMMEL, OF ALTOONA, PA.

Claim 1.—In combination with a locomotive fire box having an open end, of a closure for said open end, an inlet for receiving the exhaust steam in said closure, means in said closure for storing the water of condensation from the steam, and means for segregating the oil carried by said steam from the water of condensation. Ten claims.

1,025,710. HAND-HOLE PLATE. WILLIAM C. MORRISON, OF PITTSBURG, PA., ASSIGNOR OF ONE-HALF TO WILLIAM RICHARDSON, OF ST. LOUIS, MISS.

Claim 1.—The combination with a boiler having a hand-hole, of a hand-hole cover comprising a member having its body-portion substantially solid and of a peripheral configuration approximating that of the hand-hole, said body-portion having its rear or inner portion formed with a peripheral flange projecting outwardly, the inner faces of the flange and body-portion having substantially co-incident planes, the distance between the forward faces of the flange and body-portion being greater than the thickness of the boiler plate, said body-portion also having an integral forwardly-projecting fastening member slotted diametrically intermediate its ends, yieldable, means carried by the body-portion in advance of the flange for decreasing the distance between the flange and body-portion faces and acting as a packing for the cover, and a key insertible in the slot of the fastening member for securing the cover in position. One claim.



1,023,418. COAL FEEDER. GEORGE F. DE WEIN, OF MILWAUKEE, WIS., ASSIGNOR TO ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS., A CORPORATION OF NEW JERSEY.

Claim 1.—In a feeder, a housing, a stationary casing communicating with said housing, a shaft rotatable within said casing, a conveyer fixed to said shaft, and freely mounted within said housing a circular screen fixed to said shaft adjacent the end of said casing, said casing being adapted to discharge to the interior of said screen. Three claims.

1,026,060. BLOWER FOR BOILERS. LOUIS SPRENGER, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY COMPANY, OF DETROIT, MICH.

Claim 1.—The combination with a steam-supply pipe, of a shell, nozzles secured to said shell and projecting thereinto, a ported tube rotable in the shell, means for rotating said tube to bring its ports into register with the nozzles respectively, and means for supporting said shell for bodily swinging movement on the supply pipe to move said nozzles simultaneously and equally. Seven claims.

1,026,309. WATER GAGE. JAMES HACKETT, OF PORT COSTA, CAL.

Claim 1.—In a water gage, the combination of a valve casing having a chamber and having an internal shoulder, a glass tube mounted in said casing, a baffle plate disposed in said casing above the tube and having a flange engaging said shoulder, means on said plate for directing steam through the plate to the interior of the tube some distance below the upper end thereof, a cap fitting the casing and having a flange with openings to a space above said disk, and to the chamber of the casing, said casing having a port, and a valve for closing said port. Three claims.

1,020,234. WATER-TUBE BOILER. CHARLES WARD, OF CHARLESTON, W. VA.

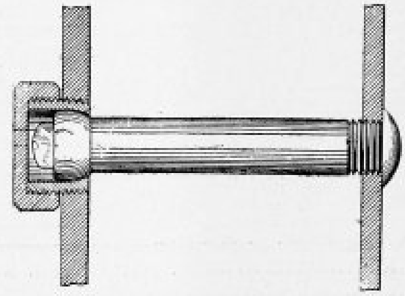
Claim 1. In a boiler, the combination with headers, of a main circulating tube passing through the headers and having openings in communication with the headers near the ends of said tube, a shaft arranged to enter one end of the said main tube, and a wheel secured upon the shaft constructed and arranged to impel the water through the openings in said tube at the same end. Eleven claims.

1,020,235. STAY FOR BOILER PLATES. CHARLES WARD AND CHARLES E. WARD, OF CHARLESTON, W. VA.

Claim 1.—A stay for boiler plates, comprising the combination with opposed plates provided with retaining grooves, of a plurality of separately removable stays arranged one after another in the same grooves and having portions constructed to engage the grooves of the plates, and the said stays having portions constructed to permit the water to pass through from one side of a row of stays to the other side thereof. Four claims.

1,025,706. STAY-BOLT CONSTRUCTION FOR STEAM BOILERS. JOHN H. McCLOY, OF GRADATIM, AND ALEXANDER M. BROWN, OF OAKMONT, PA.

Claim 2.—In combination, a stay-bolt, a socket-sleeve, and a cap, said bolt having a head integral therewith and formed spherical between two parallel planes intersecting the bolt axis at right angles, said sleeve having a seat extending to the inner end of the sleeve and formed complemental to the spherical portion of the head, the inner plane of the



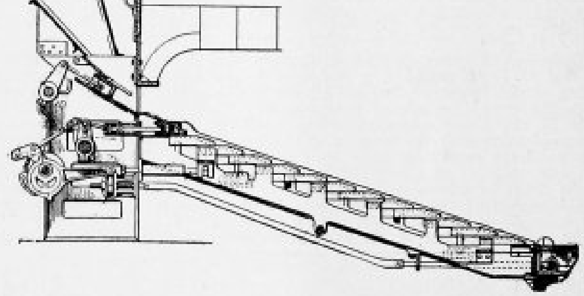
spherical portion being beyond the sleeve end to provide an exposed projecting portion of the spherical head when assembled, the relative arrangement of head and sleeve seat forming a joint free from cavities at the inner end of the sleeve, said cap being threaded to said sleeve, said bolt head having its outer end beyond the outer plane of the spherical portion reduced to form a wrench-hold. Three claims.

1,025,151. SUPERHEATER. JOHN MILNE, OF NEW YORK, N. Y.

Claim 2.—In a superheater the combination of a drum, a stationary partition extending part away from the inner surface of the drum, a movable partition in the drum coacting with the stationary partition to divide the drum into an inlet chamber and an outlet chamber, tubes outside of the drum with the ends of each connecting the chambers and means to locate the movable partition between the ends of each of said tubes. Four claims.

1,027,149. MECHANICAL STOKER. HENRY MacNUTT PARSON, OF NEW YORK, N. Y., ASSIGNOR TO PARSON MANUFACTURING COMPANY OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 1.—In a mechanical stoker, a fuel advancing grate, some of the bars of which have reciprocating movement with respect to the others,



and a movable carriage on which the reciprocating bars are so mounted as to have lost motion with respect thereto. Twenty-two claims.

1,028,083.—BOILER CLEANER. LEO JOHN BAYER, OF ST. LOUIS, MISSOURI, ASSIGNOR TO BAYER STEAM SOOT BLOWER COMPANY, OF ST. LOUIS, MISSOURI.

Claim 4.—In combination with a boiler having a watertube section baffled transversely, whereby the same is divided into sections, means distributed over the tube area at the ends of the tubes for projectng a cleaning fluid longitudinally with the tubes into a portion of the sections and transversely into another portion of the sections. Ten claims.

THE BOILER MAKER

SEPTEMBER, 1912

A New Method of Testing Boilers

BY A. L. HAAS

It has become a commonplace of the mechanical business to actually determine error as an appreciable measurement by means of easily applied devices; this is the case everywhere for mechanical products—so much so that the question of determination of error is simply a matter of refinement of measuring appliances. We have departed from a scratch on a steel scale in the estimation of end measurement, to the use of the micrometer reading to 1/1000 inch or 1/10000 inch. We now carefully estimate expansion caused by temperature, and in some work the gages used are falsified if held by the hand, the expansion becoming appreciable and liable to defeat the use of the gage. The present-day axiom is not simply to make something in which by clumsy means we can find no apparent error, but by means of refined appliances to keep within strictly fixed limits, dependent upon the character of the work in hand. In fact, error within certain close limits is now proudly guaranteed as proof of excellence of workmanship.

The question of boiler testing is a field believed by the writer to have been missed over in the modern-day passion for accuracy, and it is hoped to draw attention to possibilities of development of the guaranteed error method in boiler making.

Primarily, it is necessary to examine a method of test utilized in another direction before proceeding to the actual application to boilers.

Refrigerating machines using ammonia NH_3 are in everyday use. The gas comes to the consumer in M. S. flasks under considerable pressure. In the inception of the ice business more than one fatal accident arose from the use of faulty flasks.

A commission to determine reasonable guarantees and safeguards respecting compressed gas flasks sat in England in 1896. Their findings and recommendations were embodied in an official report. Without going into details as to pressure of loading, the principal points were that the flasks should be made of solid-drawn steel tube, the material of which must contain not more than 0.25 percent carbon and not less than 99 percent iron, that each flask must be hydraulically tested to a pressure of 1,500 pounds per square inch, and are not to show a permanent stretch or enlargement of their cubic capacity of more than 10 percent of their temporary stretch under test.

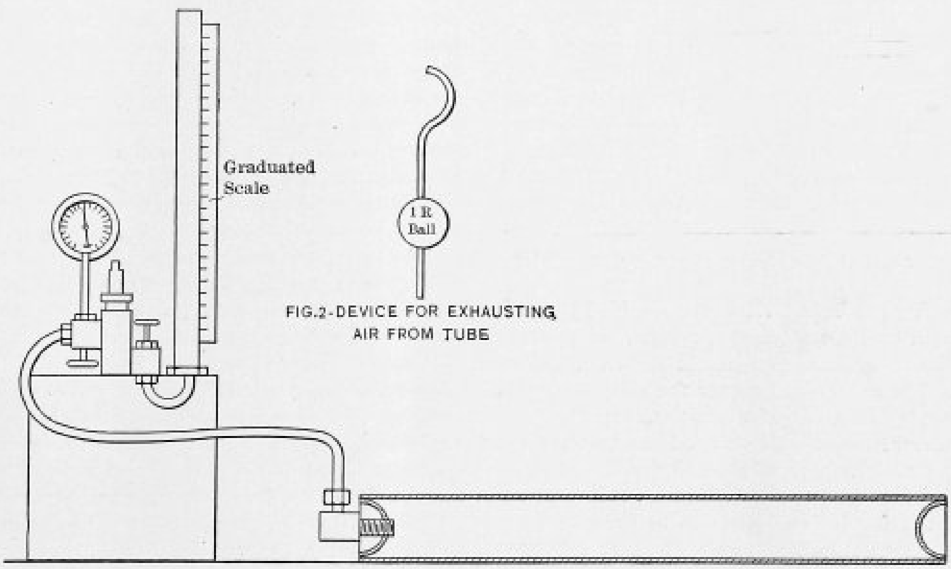


FIG. 2.-DEVICE FOR EXHAUSTING AIR FROM TUBE

FIG. 1.—DIAGRAMMATIC SKETCH OF COMPRESSED GAS FLASK TESTING APPARATUS

The method of testing and the apparatus used is shown in the sketch, Fig. 1. The flask shown under test is of the ordinary type. It consists of a piece of solid-drawn tube, 10 inches in diameter, ¼ inch thick, and does not exceed 10 feet in length in the maximum size. The ends are cupped, hemispherical stampings projecting inwards. The exposed edges of the body and end are welded. A valve is screwed into one end, the threads of both valve and flask are tinned, and after the test are sweated in solid.

The pipe leading from the pump delivery is fitted with a pressure gage. The suction of the pump communicates only to a glass tube 1¼ inches in diameter.

The flask, having been placed on end, is filled with water without the valve in place. The air pocketed between the cupped end and side of flask is removed by the rubber ball device shown in Fig. 2. The bent portion of the pipe is inserted through the water to the air pocket, and the ball, squeezed by hand, exhausts the air, allowing water to completely fill the interior of the flask. The flask is then laid on the floor after screwing the valve home and closing same, and the connection to the pump delivery is made.

First, without any measurement of the water standing in the graduated tube, 500 pounds per square inch is pumped up, the pressure is then released, the water rising back from the flask slowly up the tube. A quantity of air bubbles up through the water. Seeing that the filling was so carefully done this air, now released, must be air in suspension in the original water. When the level in the tube is steady its height by the scale at the side, graduated in inches and tenths, is noted. The pump is now used until the specified pressure is shown on the gage (1,500 pounds), the water in the tube

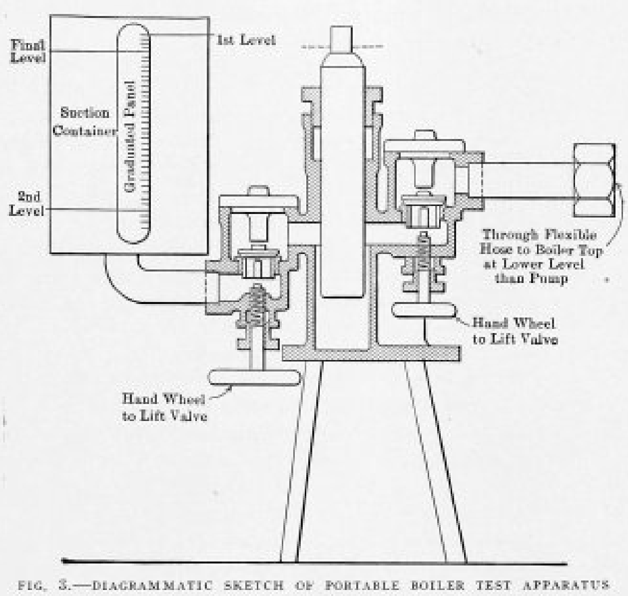


FIG. 3.—DIAGRAMMATIC SKETCH OF PORTABLE BOILER TEST APPARATUS

falling as the pumping proceeds. When the specified pressure is reached the height on the scale is again noted, the pressure is released and the water mounts again in the tube, and its final level is read. The difference between the first and second levels is the temporary stretch under the test, while the difference between the first and final levels, if any, is the apparent permanent set. The percentage of difference in terms of the maximum difference is easily calculated. In view of the application of the method to boilers to be presently outlined, the tests of a 5-foot flask 10 inches diameter subjected to this test in my presence are of interest. Two spots across the diameter in the center of the flask, about ¼-inch circle, were brightened, and while the test pressure was on the flask the diameter was callipered by a micrometer. The same spots with pressure released were again carefully measured, the difference being 9 thousandths of an inch.

The difference in level of the first and second reading (temporary stretch under test) was 22.8 inches; the difference between the first and final readings (permanent set) .1 inch. The diameter of the tube, 1¼ inch, gives a temporary enlargement of cubic capacity of 22.65 cubic inches, or .466 percent of total volume, the permanent set being .4 percent of the temporary stretch.

To return to the subject of boiler testing, sufficient emphasis is not given to the folly of blindly pumping up a boiler to test same hydraulically. Such a test simply proves that the seams are light and nothing else. Right testing needs measurement of the breathing or temporary stretch, and no boiler should ever be tested to such a pressure that permanent set or deformation results from the proving or hydraulic test. Quite 90 percent of the testing done to boilers even in this enlightened age is valueless, as reliance is placed upon simply pumping up to an excess hydraulic pressure over the steam pressure.

The reason cast iron boilers were discarded was not from insufficient strength, but partly from a thermodynamic point of view, and more essentially because cast iron is comparatively inelastic, while boilers as made to-day are elastic vessels to contain pressure. This elasticity is a vital point. Under pressure an inelastic vessel has stresses set up which cannot be calculated and may lead to rupture. The combination of heat and pressure in a boiler demands an elastic container. For this reason the materials used are specified of a given tonnage and elongation, the latter being a means of test of the material's elasticity.

To correctly test a boiler needs therefore a means of determining deformation under test, and to do this the bulging or breathing of the flat surfaces must be measured. A few simple rods between predetermined points, held vernier fashion, are used to ascertain in a rough-and-ready manner the distortion of the flat surfaces, and any considerable permanent set is thus shown. The straight edge and stretched wire lines are also used to determine the distortion of flat surfaces. The great point to be watched is permanent set, this proving that the pressure of test is excessive for the strength of the boiler.

Serious injury may therefore be done by blind pumping up regardless of deformation, this especially in boilers of venerable age. The various devices cited above have all one fault—they require time and prior access to the boiler. While many times the periodic test allows the individual responsible for the test no such access.

In the method of testing compressed gas flasks lies with minor alterations a means for the determination of the error of design and workmanship in boiler making, which also intelligently used gives instant and unmistakable warning against over-stressing and permanent injury.

Given a tight boiler and a tight pump the test pressure can be held for ten minutes at a time on the gage. From personal experience this can be done at makers' works under ordinary conditions of boiler testing.

If care is used to properly release all air in the boiler when filling, and if the small amount in suspension in the water be released in the same manner as in the gas flask test described, the amount of breathing, the measure of the boiler's elasticity (temporary stretch under test) can be directly measured. With the cubic capacity of the boiler calculated or measured when filling, such extension under test can be calculated as a percentage of the whole. Deformation of permanent set can also be readily ascertained.

The sketch Fig. 3 shows a suggested design for a testing pump for boilers, consisting of a pump mounted on a tripod stand with the suction container above the level of the pump. A graduated glass panel forms the means of measurement of the levels. The pump is provided with means to lift the valves off their seats, and a check valve on the boiler could be used to ensure tightness through the pump, this check also being fitted with means to raise same from its seat.

Three gallons would seem ample allowance for the suction container.

In use the pump would be placed at a higher level than the highest point of the boiler, the connection being to the highest fitting of the boiler top. The boiler under test could be slightly tilted, so that the point of attachment of the pump delivery could be the actual highest point of the boiler. Filling the boiler would be done from its lowest point through the lowest available fitting. Part pressure and release could be done several times to ensure the release of all air.

The pump having been attached as outlined above, the valves are lifted from their seats, and the filling proceeds until water comes into the suction container, when the procedure of the gas flask test is followed.

The suggested limits which seem reasonable would be 1 percent of total capacity as maximum temporary stretch and 1 percent of temporary stretch, the allowable permanent set.

The greatest value of the test seems to be the direct measurement data obtainable. No system of end measurement, however carefully applied, can possibly give such direct measurement of the boiler as a whole. There exists nothing in the way of its application, and the man standing by the pump can have direct visual evidence of the condition of the boiler under test.

Many times periodic test has to be made with a boiler in situ partially bricked up with flues. In many cases elaborate measurement of deformation is impossible by reason of the conditions or precluded by the time allowed for the test.

Statutory declarations as to fitness for service and pressure are mostly signed after simply pumping up the boiler to an excess pressure over the working pressure, and seeing as much of the exterior and interior surface as can be done under the circumstances. Many boilers, by reason of their construction, preclude a visual examination of the interior, and for these the test seems to possess peculiar value.

In use the suction container would give prompt notice of over-stressing and deformation. Any considerable amount of water used by the pump before the pressure reached a predetermined limit would stop the test before damage would be done.

Statutory declarations could contain clauses as to stretch and deformation which could directly fix the working pressure allowable by direct inference from the measured condition of boiler.

Nothing can, of course, take the place of careful examination by a trained eye. It seems to the writer that a test so simple and giving direct measurement data must prove of considerable value to all concerned.

The 1912 U. S. Standard for Extra Heavy Flanges

The American Socety of Mechanical Engineers is a large factor in promoting the industrial progress of the United States. This is usually accomplished by public-spirited members serving on committees appointed for special tasks. The most recent development, recommended jointly by the society and the National Association of Master Steam and Hot Water Fitters, is the schedule of standard weight and extra heavy flanged fittings and flanges known as "The 1912 U. S. Standard." This work has been performed on request and the changes have been made for engineering reasons. They refer particularly to heavy work and to the sizes above 9 inches. The above being true, these changes would affect principally the large consumers of great responsibility where safety is essential and where no expense would be considered too great which would prevent accident and secure continuity of service.

The various makes of flanges and fittings now on the market, figured on the basis of the bolt stress, show a factor of safety in many cases as low as two and in a few cases even less. This compared with the necessary factor of safety of the pipe itself, which is approximately sixteen, shows at a glance the necessity for the changes made in "The 1912 U. S. Standard," or bringing up the factor of safety in the bolts, flanges and fittings, especially in view of the enormous strains encountered due to changes of temperature.

The other important feature in "The 1912 U. S. Standard" is the uniformity of dimensions providing for interchangeability of fittings. Until very recently each manufacturer had his own standard and chaos has resulted, so that the engineer must know what particular make is to be purchased before he can proceed to design or erect the piping work. Hereafter all fittings of all manufacturers who comply with the new schedule will be uniform in the principal dimensions, and this will be an important factor in obtaining quickly spare parts throughout the country and enable one readily to make repairs and alterations. The new standard does not attempt to fix the quality of the metal or the thickness of the shell of fittings, leaving this to the manufacturers to regulate in accordance with their guarantee, depending on the pressure the fittings are to carry.

Standard Weight Flanges

In comparing the 1912 U. S. Schedule of Standard Weight Flanges with the alternative standard submitted by the subcommittee of manufacturers with respect to diameter of bolt circle, number of bolts and diameter of bolt holes, we find they are identical, with the one exception that the United States standard gives 7/8 inch instead of 3/4 inch for diameter of bolt hole for 4-inch pipe.

The standard of the Engineering Standards Committee of Great Britain and the standard of the Verein deutscher Ingenieure do not have sizes exactly corresponding to the standard weight and extra heavy weight of "The 1912 U. S. Standard," but have the most important dimensions, the same for all pressures, making their piping on low pressure unnecessarily heavy and expensive, but without securing absolute safety for high pressures. Comparing the proposed manufacturers' standard with British standard pipe flanges for working steam pressures of 225 pounds per square inch, we find the British standards give higher values, especially as number of bolts are concerned.

Extra Heavy Flanges

For extra heavy flanges up to 9 inches inclusive, "The 1912 U. S. Standard" and the standard of most manufacturers are identical. Above 9 inches the United States standard is somewhat larger than the present standards, as has been stated. With the British standard the diameter of bolt circle and number of bolts are the same for pipes corresponding to "The 1912 U. S. Standard," or proposed manufacturers' standard weight and extra heavy weight, but from 10 inches on the diameter of the bolt circle is from 1/4 to 1/2 inch less than the proposed manufacturers' standard and 3/4 inch less than the United States standard. The number of bolts in most cases for pipes from 10 inches on in the United States 1912 and manufacturers' is from two to four bolts greater than in the British standard. As far as size of bolts is concerned the British standard makes a distinction between pipes for pressures up to 225 pounds and up to 325 pounds. The bolts for pipes up to 225 pounds are below the manufacturers' standard 1/8 inch in nearly every case, and below the United States standard from 1/8 to 3/8 inch. In pipes for pressure of 325 pounds the British standard is the same as the proposed manufacturers' schedule in all cases except 14 inches and 18 inches where the British standard is 1/8 inch larger than the manufacturers' standard, but from 1/8 to 1/4 inch smaller than the United States standard.

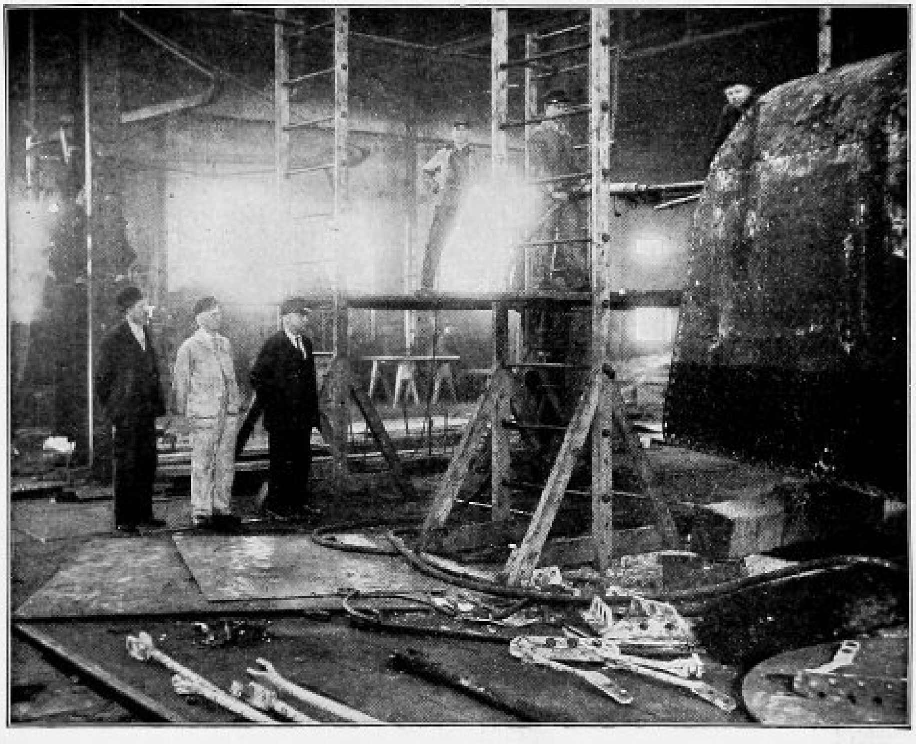
It is thus seen that wherever there is a distinction between the 1912 United States and proposed manufacturers' standard, "The 1912 U. S. Standard" is invariably on the side of greater safety and strength, and has the added feature of interchangeability where the proposed manufacturers' schedule has different face to face dimensions. As to the comparison with the British and German standards it must be remembered that they cover by one standard both weights of the American specifications, and as would be naturally expected with compromises must have higher values for standard weight pipes and lower values for extra heavy weight pipes. However, in Germany there is reported in the public press dissatisfaction with the existing standards as not being safe. The Alsace Association of Owners of Steam Machinery prints in its annual report for 1911 as follows:

"It is nearly impossible to estimate with any degree of precision the bending stresses to which are submitted pipe flanges when, in order to obtain a good joint, the bolts are screwed tightly, especially if the flange has to withstand at the same time stresses due to expansion. As a result, many of the joints in pipes and similar apparatus are working with very low factors of safety, as has been shown lately by the fact that accidents from piping have been far more numerous than from boilers, and with as fatal consequences."

"The 1912 U. S. Standard" is the result of the efforts of the aforementioned committees covering a period of over a year during which time every detail was considered. The committee had the active co-operation of engineers representing large power plants, manufacturers and the United States Navy Department. Prominent engineers and architects throughout the country were communicated with and their opinions and advice received and considered, and the final consummation is "The 1912 U. S. Standard."

This standard has been in operation two months and has already been approved and adopted by the United States Navy Department, United States Bureau of Standards, Isthmian Canal Commission, and is under consideration by other departments of the United States Government. Large power concerns, such as the Interborough Rapid Transit Company of New York, the New York Edison Company and others who in the past have had fittings made from their own patterns, because there was no standard, have agreed to adopt and use "The 1912 U. S. Standard." Mr. L. B. Stillwell, electrical engineer of New York, has specified "The 1912 U. S. Standard" for fittings in the new 120,000-kilowatt power house now in process of construction at Hauto, Pa., by the Lehigh Navigation Electric Company. We are informed that manufacturers are beginning to fill orders, and in some cases are preparing the dimensions in their own new catalogues in accordance with "The 1912 U. S. Standard." The committee of the American Society of Mechanical Engineers have decided, after the most careful consideration, not to reopen the subject, as has been erroneously reported.

This schedule was published in the February, 1912, *Journal* of the American Society of Mechanical Engineers and February, 1912, *Bulletin* of the National Association of Master Steam and Hot Water Fitters, and copies may be had upon request from either the National Association of Master Steam and Hot Water Fitters or the American Society of Mechanical Engineers.



RIVET BUSTER IN USE AT THE BRAINERD SHOPS OF THE NORTHERN PACIFIC

A Rivet Buster at Work

We are indebted to *Ideal Power* for the accompanying cut and description of the Boyer rivet buster, made by the Chicago Pneumatic Tool Company, which is in use at the Brainerd shops of the Northern Pacific Railway Company. With this machine 1,530 stay-bolts and 360 combination bolts were cut out in twelve hours, which would otherwise have required fifty hours. They also cut off six hundred 1⅛-inch and ⅞-inch rivets in nine hours, which includes back head, mud-ring, front flue sheet, smoke-arch ring, braces, etc. The three gentlemen in the picture are Mr. Edwards, foreman boiler maker, who has been with the Northern Pacific for thirty years; Mr. Creger, his assistant, who learned his trade there and has been with them a long time, and Mr. Corkrey, tool room foreman, who is an expert in his line.

Water Treatment and Boiler Troubles*

By W. A. Pownall

When water falls to the earth as rain or snow some of it runs over the surface of the ground into the lakes and streams, and some of it passes into the ground and reappears in springs, wells or in lakes and streams into which it has entered from below. In either case the water dissolves from the surface or from the rocks and earth through which it seeps, a certain amount of mineral matter, and when pumped it contains two classes of mineral salts, the amounts of which determine its degree of fitness for use in locomotive boilers. These are the incrusting salts and the alkali salts; the sum of the two would represent the total solids dissolved in the water and would be the residue left on evaporation.

Total Dissolved Solids—Incrusting salts or total hardness: Carbonate of lime and magnesia (carbonate hardness), sulphate of lime and magnesia (sulphate hardness). Alkali salts: Sodium sulphate, sodium chloride, sodium carbonate.

Incrusting Salts

The incrusting salts or total hardness may be divided into the carbonate hardness or carbonates of lime and magnesia and the sulphate hardness or sulphates of lime and magnesia. These are perhaps more commonly known as the "temporary" and the "permanent" hardnesses. When water is boiled at atmospheric pressure the carbonate hardness is precipitated either as a soft mud or a bulky scale on the flues and staybolts, according to the condition of the water in the boiler. The sulphate hardness remains in solution when water is boiled at pressure below 60 pounds, but above this pressure it separates out and forms a hard scale on flues and firebox sheets, the result of which is continual trouble from leaky flues, staybolts and fireboxes due to overheating of the metal.

Alkali Salts

The difference between the total dissolved solids and the total hardness would represent the "alkali" salts or the sulphates, chlorides and carbonates of sodium. These salts remain in solution after the water has been boiled, and when the total amount in the boiler reaches a certain concentration the boiler begins to foam. Waters high in alkali salts are, on account of their tendency to cause foaming, undesirable for boiler purposes.

In addition to these mineral salts surface waters, especially the streams, at times carry large amounts of suspended matter (mud), and this may cause trouble, if the water in the boiler is in a scale forming condition, by baking on the flues or building in to form a heavier scale. The foaming tendency of the water is also aggravated by this mud and by any decayed animal and vegetable matter that may be found in some waters.

The amount and proportions of these mineral salts found in waters vary considerably in different parts of the country. In the territory covered by the C. B. & Q. R. R. the waters are found as follows:

In Illinois the surface waters all contain more or less sulphate hardness and are low in alkali salts. In Iowa and Missouri the surface waters are lower in sulphate hardness and about the same in alkali as the Illinois waters. Shallow wells in these States furnish, with few exceptions, much harder water than the surface supplies. Some wells of moderate depth in sandstone furnish waters containing free sodium carbonate (soda ash), if they are comparatively near the outcrop of the sandstone, and waters of this type, if not too high in alkali, are desirable, as they are non-incrusting. West of Missouri River in Nebraska well waters as a rule are either low in sulphate hardness or contain free sodium carbonate; these waters, however, increase in the amount of alkali salts as we go westward and have therefore a greater foaming tendency. In Wyoming and South Dakota there are some fairly good quality surface waters, but generally speaking the waters, surface and well, are high in both sulphate hardness and alkali salts and it is a case of take what you can get. Some wells in these States furnish waters high in sodium carbonate but with hardly any incrusting water, and while these are foaming waters they are preferable to the waters that are incrusting as well as foaming.

Causes of Boiler Trouble

The primary cause of leaky flues, fireboxes and staybolts is unequal expansion and contraction brought about by overheating of the metal due to it being insulated from the water by a layer of scale formed by the precipitation of the lime and magnesia salts in the water. These troubles will be accentuated by any sudden cooling of the metal such as might be caused by holes in the fire, working engine very hard and then suddenly shutting off steam and leaving shut off for some time, cold water from injector falling to bottom of boiler and to washing boilers with cold water. Proper firing will take care of the holes in the fire. There are hilly divisions of such character that it is necessary to work engine very hard up to top of grade and then drift down to bottom, and, unless the flues are kept free from scale, there will be considerable trouble from leaky flues under these conditions. Numerous arrangements are in use for preheating the water entering the boiler, and one of these, a cheap, simple and effective device for doing this, is simply a cast iron elbow screwed into the boiler check and pointed upwards so that the water from injector shoots up and is heated as it enters the boiler instead of dropping cold to the bottom. With this upturned elbow the difference in temperature between the water in the bottom of the boiler and near water level will only be about 10 degrees F., while a full glass of water is being fed and the engine is standing still; with the ordinary boiler check this difference will run from 80 to 100 degrees.

There are also a number of different kinds of hot water washing plants that supply hot water blown out from boilers for washing out and hot fresh water for filling boilers. An inexpensive plant consists of a sump into which the water and steam from engines to be washed are blown, enough fresh water being let into the sump to provide the necessary total for washing and filling. There should be some kind of a hot water washout plant at all places where any number of engines are washed, and all engines ought to have some device for heating the water before or as it enters the boiler.

These precautions will avoid sudden cooling, but the important thing is to avoid overheating. If there is no insulating layer of scale on the metal it will never get much more than fifty degrees hotter than the temperature of the water in the boiler, so that even with the cooling effects present the total temperature variation will not be large enough to cause much trouble. As water in the boiler at 200 pounds pressure will be at 387 degrees F., the maximum temperature of clean flue ends would be perhaps 440 degrees F., whereas with a heavy coating of scale these would get as hot as 1,000 degrees F., or even hotter. The remedy for most of the trouble then is to prevent overheating by avoiding the scale formation, and this is done by proper chemical treatment of the feed water.

* From a paper read before the Western Railway Club, April, 1912.

It is not intended to assert that water treatment is the absolute cure for boiler troubles; the boiler work must be done right. For example, one thing that is liable to keep flues leaking is the misuse of the beading tool. If this tool is held incorrectly, as is the tendency in working the lower flues (which are also the ones most liable to leak), these flues, though the leaking is stopped temporarily, will soon start again when engine goes out on road. The bead may be set up against the sheet all right; but the joint in the flue hole, which to prevent leaking should be good, is gradually made worse and worse until it is nearly impossible to keep flues tight. With proper water treatment, there may be leaky flues due to careless boiler work, but if water treatment is insufficient to prevent flues from scaling they are very liable to leak even with the best of care by the boiler maker.

I think all will agree that where waters that do not form scale are used boiler troubles are rare, and if we haven't such waters the obvious thing to do is to put the waters that we do have in a non-scaling condition.

Treatment

There are then two evils that are to be counteracted in a boiler water, the tendency to form scale and the tendency to foam. To remove the scaling tendency several different kinds of water softeners are in use. These use slaked lime to precipitate the carbonates of lime and magnesia, and soda ash to treat the sulphate hardness; so that the resultant water as delivered to boilers, if the water softener is designed to allow plenty of time for chemical reaction and settling and is properly looked after, contains only about six parts per 100,000 of total hardness, and is also cleared of most of whatever mud may have been in the original water.

Experience has shown that if waters are treated with enough soda ash to neutralize the sulphate hardness and provide enough excess to have it amount to about 15 percent of the total dissolved solids in the water from the boiler, all of the scale forming material, both carbonates and sulphates, although it goes into the boiler, will be converted into a soft sludge which can be blown out through a properly located blow-off, and there will be no scale formation with its attendant boiler leaking troubles. Soda ash or sodium carbonate is one of the alkali salts that exists in some waters naturally, but it does not exist in the same water with sulphate of lime, as the two would react to form sulphate of sodium and carbonate of lime. If then a water containing sulphate of lime is treated with soda ash this same reaction takes place, perhaps partly in the supply tank but mostly in the boiler, and the carbonate of lime is thrown down as a mud while the sodium sulphate stays in solution, thereby increasing the alkali salts or foaming tendency of the water.

As pointed out before, when the concentration of the alkali salts, which include the natural alkali in the raw water and that added as soda ash, reaches a certain point foaming results. This foaming point varies with different types of boiler and also with the height of water carried in the glass, but in districts where surface supplies carrying more or less suspended matter are used boilers are usually in a foaming condition when the total dissolved solids in water taken from the boiler are over 200 parts per 100,000. Where only well waters are used this limit will be about 250 parts per 100,000 or even higher. When the foaming point is reached either the boiler is washed, the water changed, or part of the concentrated water is blown out and replaced with fresh water, this being done often enough to always keep the total dissolved solids below the foaming limit of 200 or 250 parts per 100,000 as the case may be.

The mud and carbonates precipitated in the boiler if allowed to accumulate may cause trouble in three ways:

1. The foaming tendency of the water in the boiler increases.
2. Heavier scale will form at times when treatment is light.
3. There is danger from mud-burning.

It is essential, therefore, that engines using treated water be equipped with suitable blow-off arrangement for removing this sludge from the boiler. The circulation of water in the locomotive boiler is along the bottom toward the back water leg, where it is least rapid, and all solid particles light enough to be moved by the current are carried back toward that point. When there is scale formation in the boiler the heavier pieces of scale drop out in the belly and in the front of the side legs, while the lighter scales and mud are deposited in the back of the side legs and in the back water leg.

If the water has been treated with the proper amount of soda ash there will be practically no scale formation, and the lime and magnesia carbonate sludge will deposit in the back water leg, from which it can be removed by means of a perforated pipe extending across and lying on the back mud ring and connected to a blow-off cock located in the back corner.

Where muddy waters are used, a great deal of the mud can be kept out of boilers by equipping the supply tubs with float pipes so that water going to water cranes or down spouts is always drawn from near surface of water in tank. Advantage is thus taken of the natural settling of the mud in the water.

The primary purpose of the blow-off cock where soda ash is used is to replace part of the highly concentrated water in the boiler with fresh water from the tank in order to keep the total dissolved solids in the water below the foaming point. Although the removal of the sludge and suspended matter in the boiler is important, it is incidental to keeping the concentration of the dissolved solids down; but the blow-off cock has to be used often enough for the first named reason to keep the boiler always in good condition from the sludge standpoint. Where fully treated water is used and engines are equipped with this blow-off arrangement, engines, if systematically blown off, can be kept in good condition and will run indefinitely without having to wash out boiler. This has been demonstrated by tests and in practice. One division that has treated water and has given this matter considerable attention, averaged for one year 4,000 miles per washout for all engines on the division.

It is, of course, not advisable to run very far without washing if water is not treated fully and continuously enough to prevent scale accumulation. It is difficult to get out of the habit of washing engines every two or three trips, but where treatment is complete and properly looked after there is no reason for taking the water out of the boiler except through blowing off and at the stated period when the Federal Law says the boiler must be washed.

The mere fact that water has been treated with soda ash does not make it a badly foaming water. The average Illinois water treated does not contain as much alkali and therefore has not as strong a foaming tendency as the Nebraska water untreated, and an engine will reach the foaming point and need blowing off or water changed sooner when it uses the waters higher in alkali whether that alkali is there naturally or whether it was introduced in the form of soda ash.

Amount of Blowing Out Necessary

The amount of blowing off that has to be done to keep water in boiler below foaming point of 200 or 250 parts per 100,000 depends on the amount of water used, the amount of soda ash used, and the natural alkali in the raw water. Stream waters in Illinois contain perhaps two parts natural alkali and are treated with eight parts soda ash (this corresponds to 2/3 pounds soda ash per 1,000 gallons), making a total of ten parts alkali salts per 100,000 in the water as fed to the boiler, so that when $\frac{200}{10} = 20$ boilers of water are evaporated water will be at the foaming point, and it is necessary to either change the water completely or do enough blowing to prevent concentration rising over 200; in this case to effect this result it will be necessary to blow away $\frac{10}{200}$ or 5 percent of the water used. At 15,000 gallons water used per 100 miles, this will mean 750 gallons, and as a 1½-inch blow-off cock under 200 pounds pressure will let out about 150 gallons per minute, a total blowing of $\frac{750}{150} =$ five minutes will be necessary to keep boiler from foaming. A minute's blowing on heavy power is about two inches in the glass, five minutes means 10 inches, and this may be done at terminals or on road. Passenger engines ordinarily can be blown enough at terminals to keep them in good condition indefinitely, but freight engines will have to have more or less blowing done on the road as well as at terminals. Where heavy and frequent blowing is necessary operating conditions do not always permit blowing in time and then engine works water. An instance of this sort is where there is a continuous upgrade for 150 miles, water runs high in alkali, necessitating heavy blowing, and about the only time freight engines can get ahead enough on water to do the blowing is where they stop at stations. Heavier blowing out has to be done, as the total of natural alkali and alkali added as soda ash is higher, and with waters on some divisions the necessary blowing would more than offset the saving in cost of washout and advantage of not holding engine for washout. When this limiting condition is reached it will be cheaper to change water with an occasional washout than to rely entirely on blowing out. There are worse conditions than this, for some waters will run so high in alkali that the use of an anti-foaming compound which raises the foaming point of the water to perhaps 600 parts per 100,000 is necessary for engine to make even one round trip without foaming trouble.

Cost of Blowing Out

The amount of coal wasted at blow-off cock per one minute of blowing would be 50 pounds, figuring 150 gallons = 1,250 pounds water blown out per minute and that one pound coal will heat 25 pounds of water to the temperature of water leaving blow-off cock. With coal at $2.00 per ton and water at 5 cents per 1,000 gallons this would amount to $0.05 per minute for coal and $0.0075 for water, a total of $0.0575.

There are several objections against extensive use of the blow-off cock on the road. In passenger service it is impractical to open the blow-off cock on the road, and in freight service it is objectionable on account of heavy drain on boiler in small space of time, whitewashing company property and complaint because of noise and dirtying of property of people residing along the line. Where the country is fairly closely populated and in a number of towns people object so strenuously to the noise and splash of the blow-off cock that it has been necessary to issue orders not to use it at these places, and enginemen often find themselves hard put for an opportunity to blow their boilers. Blow-off boxes so located at intermediate water stations that engine can be blown while taking water relieve the situation materially, but what promises to help solve the problem is the use of a blow-off cock with opening so restricted that instead of a large amount of water being let out of boiler in a short space of time the blowing goes on continuously for an hour or more as the condition demands. An opening ¼ inch in diameter will allow about 450 gallons or six inches in the glass to leak away in an hour, and this seems to be a satisfactory size for the continuous blow-off. Where the necessary blowing per 100 miles is 750 gallons, the ¼-inch blow-off cock, if kept open $\frac{750}{450} = 1\ 2/3$ hours, would keep the boiler in good condition without having to use main blow-off cock at all. About the only time when it is impractical to use the ¼-inch blow-off is when engine is working hard up-grade, and taking all the water one injector will supply; but there is usually plenty of opportunity over the division to use it all that is necessary.

The primary purpose of a blow-off cock is to get rid of the concentrated water in the boiler; the ¼-inch blow-off cock does this and actual test has shown that if properly located it also carries away a great deal of the suspended lime sludge. A Pacific type passenger engine with one of these ¼-inch cocks in back corner near mud ring and with regular blow-off cock disconnected so that it could not be used made, experimentally, 10,000 miles in fast passenger service without washout or change of water. The average treatment of the water used was ½ pound soda ash per 1,000 gallons, the average total hardness was about 28 parts per 100,000 (or 16 grains per gallon), yet when boiler was opened for washout it was practically clear of sludge and had only small deposits of old scale in the side water legs. Blow-off cock was kept open about two hours over a 150-mile run. The experience has been that small valves soon cut out, and the best arrangement is the ordinary 1½-inch blow-off cock with bushing bored out ¼ inch in diameter.

The reason for dwelling at such length on the blowing off is that the success of soda ash treatment in a large measure depends upon it. The use of soda ash increases the foaming tendency of the water, and when the foaming point is reached, if the water is not gotten rid of through the blow-off cock, it will depart via the cylinders and valves, causing heavy use of oil, dissatisfaction of the enginemen and various machinery failures.

Procedure in Starting Soda-Ash Treatment

How then shall a certain division be equipped to avoid boiler troubles? We must first get the best available water supplies; second, provide suitable arrangements for blowing off engines and line up to have engines blown systematically at terminals and on road; third, treat all waters containing sulphate hardness with the necessary amount of soda ash; and fourth, provide sufficient chemical inspection to maintain correct treatment at all times.

Water Supplies

Chemical analyses of the waters in use for locomotives should be made, and where the sulphate hardness or the alkali salts are high an effort should be made to locate a better supply that can be substituted at a not prohibitive expense. Often water is taken from a well at the bank of a stream and is much harder water than the stream water; it is easy here to discontinue well and pump from the stream. Open dug wells will furnish bad water when bored wells of the same depth will, by excluding surface water, furnish a good water. Bored wells tapping different rock strata furnish waters of different qualities, and the well giving the best quality should be used, casting off any objectionable waters from other strata. Frequently the underground waters at a station may all be bad, and the artificial surface reservoir is a good solution of the problem (as it will usually furnish a fairly good grade of water). The quality of the water from a surface reservoir depends on the character of the ground on the drainage area; if there is much limestone, gypsum or alkali on the drainage area, as is often the case between Western Nebraska and the Rocky Mountains and in some cases further east, the water that collects in the reservoir may be very bad. This is contrary to a prevailing belief that rain water being soft, the reservoir water will also be soft. Analyses of a number of samples of run-off water from drainage area of proposed reservoir should be made to determine the probable fitness of the water before building the dam, otherwise considerable money may be spent in getting a water supply that will be unusable for boilers.

For every six parts of alkali salts per 100,000 a cent's worth of coal at $2.00 per ton will be wasted at blow-off cock per 1,000 gallons water used, in order to keep water in the boiler below foaming point of 200 parts per 100,000.

With the better water there would be a saving in cost of soda ash and coal wasted in blowing off of six cents per 1,000 gallons, much less blowing would be necessary, and there would be less liability to boiler troubles if treatment were neglected or stopped temporarily.

Blowing Off Boilers

The proper blowing off of engines where water treated with soda ash is used is of utmost importance to avoid foaming failures and excessive use of valve oil, and it is wise to have this lined up pretty well before starting the soda ash. At terminal round-houses there should be a place for blowing off engine just before it goes onto clinker-pit, and it is also a good plan to provide a similar arrangement on outgoing track to give enginemen opportunity to blow off before leaving. Pipe from blow-off cocks should be located the same on all engines and the end of the pipe provided with a threaded nut to enable it to be connected to a steam hose. Then a blow-off box may be used, or where the noise or steam is objectionable engine may be blown through a hose into a sump. Terminal blowing may be done by hostlers or at important terminals there may be one man whose duty is to blow a full glass of water from every incoming engine.

Treatment

All waters containing sulphate hardness should be treated with enough soda ash to neutralize this sulphate and have treated water show excess of sodium carbonate from one to four parts per 100,000. This excess should be such that waters taken from boilers of road engines will have 15 percent or more of the total dissolved solids as sodium carbonate (soda ash). The soda-ash solution would best be introduced evenly and continuously and should go through separate pipe into the water tank so there will be a chance for chemical reaction before the treated water passes into any pipe lines. With practically all water, putting the soda-ash solution into the discharge pipe from main pump will result in liming up of this pipe, which sooner or later results in closing the pipe to such an extent as to necessitate cleaning it out or laying a new pipe.

Any of the following plans may be used for introducing the soda ash:

1. Steam pumping station with tank within 800 feet.

Connect small plunger pump to main pump and pump soda-ash solution from 100-gallon galvanized iron tank through 2-inch pipe to supply tank; or, use small duplex steam pump to pump solution from a 300 to 600-gallon solution tank.

2. Gasoline engine pumping station with tank within 800 feet.

Connect small plunger pump direct to main pump or run it by eccentric or extension shaft and pump solution as in (1).

3. Tanks at terminals where city water is used or where pumping station is remote.

(*a*) Use small duplex steam pump as in (1) and pump solution continuously.

(*b*) Where compressed air is available force soda-ash solution from closed tank continuously to supply tank. Solution pipe runs to top of the supply tank to give constant back pressure and the air to solution tank passes through a reducing valve that maintains a constant pressure 5 pounds greater than the back pressure. Solution is forced through a perforated metal gasket, the amount of flow required being governed by size of perforation. This is preferable to the pump as it forces the solution evenly, and the only attention needed is to mix the solution every 24 hours.

4. Pumping station and supply tank over 800 feet apart or where city water is used.

(*a*) All water pumped passes through a large water motor, which operates a plunger pump to pump the soda ash solution to supply tank. This is in a building close to tank and must be provided with heat in winter.

(*b*) An automatic treating plant, with no moving parts to get out of order and one that needs only the attention of charging every twenty-four hours, is located in a house near supply tank. Its operation is as follows:

There is an open tank for mixing soda ash, a closed soda ash tank and a closed air reservoir. A perforated metal gasket in main pipe line causes a difference in pressure of about 4 pounds between the two sides of this gasket. Size of hole in gasket can be calculated from average flow of water. A pipe leads from high-pressure side of gasket to air tank. The air pressure created there is transmitted through a small pipe to top of closed soda ash tank, and forces solution through a gasket with small hole to supply tank through separate soda ash line. Charging plant consists of emptying air tank of accumulated water, mixing soda ash in open tank and letting it into closed soda ash tank. Flow of solution is regulated by size of hole in gasket in soda ash line so that plants will run twenty-four hours to one charging.

5. At tanks where little water is used fairly even results can be obtained by suspending the soda ash every twelve or twenty-four hours in a burlap sack in supply tank. It is difficult to get this done in severe weather, and the method is unreliable.

Supervision of Treatment

A very important feature of treating waters with soda ash alone is to provide enough chemical inspection and supervision to insure keeping all waters treated fully and with as little interruption as possible. If the treatment is a little light on account of neglect of pumpers or insufficient soda ash called for in directions, so that the treated waters in general still show some sulphate hardness, then the only benefit is in the small decrease in hardness of the water, due to some precipitation of the lime corbonate in the supply tub. The foaming tendency of the water will have increased in proportion to the amount of soda ash used, and boiler must be blown off nearly as much as with full treatment; but the hard scale still forms on the flues and causes the leaking troubles that the soda ash is expected to cure. To keep treatment right a road water inspector should make frequent analyses of the raw and treated waters for sulphate hardness or sodium carbonate, and should also inspect apparatus for treatment. If this inspection shows treatment wrong he should do what he can on the ground toward adjusting matters, and report to division officials when other steps are necessary to correct pumper or repair apparatus. Men handling the soda-ash treatment, whether pumpers, agents or section men, should be lined up to report at once to superior officer whenever for any reason the soda ash cannot be used properly, and the complaint should be given prompt attention and necessary repairs made. On some divisions the interruption of correct treatment even for a short time causes an epidemic of leaky boilers, and it is on divisions like this where frequent chemical inspection is important. It is better to keep ahead of the trouble than it is to have trouble and then send a man to locate the cause. On some divisions where the raw waters do not vary much in quality at different times of the year, and where there is a dependable class of men handling the soda ash, it will not be necessary to provide so much chemical supervision after treatment has been started and is going satisfactorily, and one water inspector may be able to handle two or three such divisions. On other divisions where the waters vary considerably in quality, where the pumpers, etc., are changing frequently, or where slight falling off in treatment is followed quickly by boilers leaking, it pays to keep a water inspector on the division all the time.

The best criterion of the condition of the treatment over any part of the road is gotten from the analyses of waters taken from boilers of road engines. These waters can be collected by the round-house force, properly tagged, and sent to the laboratory to be analyzed for total dissolved solids and for sodium carbonate. If the total dissolved solids are above the 200 or 250 parts per 100,000 according to the locality, then not enough blowing is being done to keep water in boiler from foaming condition; this will sometimes show that certain engineers are neglecting the blowing, and they can be instructed accordingly. If the soda ash is below 15 percent of the total dissolved solids the treatment is light somewhere, and inspector can make necessary increases in soda ash or perhaps locate some neglect. The following form shows a method of reporting to division officials results of these analyses:

To ———— M. M., Chicago, Ill.:

I have analyzed samples of water collected at Chicago, Ill., taken from boilers and find as follows, results expressed in parts per 100,000:

Eng.	From	Date. 1911.	Total Diss. Solids.	Total Hardness.	Sodium Carbonate	Percent. Sod. Carb. to Total Dis. Solids	Engr.
1952	Chicago	11-20	242	1.5	36.5	15.0	Scott
1960	"	"	230	1.4	50.6	22.0	Perkins
1910	"	11-19	270	1.6	37.4	13.3	Marshall
1941	"	11-20	202	1.7	30.3	15.0	Dur
2903	"	11-13	234	3.3	32.7	13.9	Bosworth
1952	"	11-12	218	3.0	33.0	15.1	Ray
2802	"	11-13	219	1.8	45.2	20.6	Monks
2848	"	"	193	2.1	41.9	21.7	Brown
2809	"	"	174	2.6	37.4	21.4	Ford
1927	"	11-12	251	1.8	35.2	14.0	Radcliffe
1959	"	11-13	246	2.5	29.5	11.9	Canfield

Remarks.—To prevent scale formation and leaking flues, waters should be treated so that there will be over 15 percent sodium carbonate to total dissolved solids. To prevent foaming, enough blowing should be done to keep total solids below 250 parts per 100,000.

RESULTS OF TREATMENT

The advantages gained by full and systematic treatment of water are as follows:

1. Engine failures due to leaky boilers are reduced to a minimum. On divisions where soda-ash treatment has been in use for several years the records show an average mileage per engine failure, due to leaky flues, of 513,000 miles. The total yearly mileage on these divisions is about 10,000,000, all waters are treated, and most of the engines are heavy power, with flues 19 and 21 feet long.

2. Much less boiler work is needed, mileage of flues between shopping is materially increased, and the cost of boiler repairs is correspondingly decreased. It is not necessary to shop an engine for flues before the machinery needs it.

3. Mileage between washings of boiler is increased.

4. There is a saving of fuel, due to having boiler free from scale. Also a saving of the fuel that heats the water lost from leaking boilers.

5. Engine is not held out of service so much for washing and working on boiler.

The disadvantages are the increased foaming tendency of the treated water and the waste of coal and water in blowing off to overcome this foaming tendency.

The cost of water treatment can be given fairly closely, but it is rather difficult to give in dollars and cents the various savings due to treatment. Some estimates of these costs and savings are given here as so much per engine per year.

COST OF TREATMENT

Soda Ash

The average amount of soda ash used per engine per year on divisions with modern treatment will be about 1,700 pounds, which at a cent a pound will be $17.00 per engine per year.

Coal Wasted at Blow-Off Cock

Every pound of soda ash used per 1,000 gallons of water increases the alkali salts by 12 parts per 100,000, and when 17 pounds have been used the foaming point of 200 parts is reached and water must be blown out. Therefore for every pound soda ash used 1/17 of 1,000 gallons of water = approximately 500 pounds of water must be wasted at blow-off cock, and assuming that 1 pound coal heats 25 pounds of water to the boiling point at 200 pounds pressure, it will take 20 pounds of coal. With coal at $2.00 per ton this will cost 2 cents per pound soda ash, or $0.02 × 1,700 = $34.00 per engine per year.

Water Wasted at Blow-Off Cock

As each pound of soda ash used requires blowing out 1/17 of 1,000 gallons of water, 1,700 pounds would require blowing out 100,000 gallons, which at 5 cents per 1,000 gallons, would be $5.00 per engine per year.

Supervision

The cost of supervision of treatment, including chemical inspection, will not amount to over $10.00 per engine per year, and should decrease as the efficiency of keeping up treatment increases.

BLOWING-OFF AT CLINKER PIT

Extra labor may be employed at some terminals for blowing out engines. This charge and the cost of maintaining blow-off hose at the various clinker pits will be about $5.00 per engine per year.

SAVINGS

Boiler Repairs

The saving that can be made in cost of boiler repairs will vary for different localities, and depends on the quality of the waters in use on the division to be treated. Where the waters are bad the heavy boiler work necessary means high cost of boiler repairs, and water treatment will result in a much larger saving than on divisions where the waters are of good quality and the expense of boiler work is ordinarily not high. An estimate of the average possible saving in cost of boiler repairs, running and general, will be $250 per engine per year. This may be high under some conditions and low for others.

Fuel Saving

There are various estimates as to the amount of fuel saved by clean flues versus flues with scale of different thickness, and tests of locomotive boilers have shown a saving of 10 percent in clean flues over flues with 1/16-inch scale. As boilers using untreated water start out of shop clean, and even after scaled, some of the scale is continually cracking off, the average saving of fuel would probably not be as high as 10 percent. It seems as though 3 percent is a conservative estimate, and with an average fuel bill of $4,000 per engine per year this would amount to $120.

Washing Boilers

Where waters are properly treated and engines are equipped with blow-off pipe in back water leg, it is practical to run boilers the month allowed by the Federal law (this is true in general, but does not apply to divisions where the natural alkali in the water is so high that a change in water is cheaper than blowing off). If engines receive ordinarily forty wash-outs per year at a cost of $1.50 per wash, or $60 total, two-thirds of this can be saved, or $40 per year.

Increased Service

An engine is out of service due to running repairs, general repairs and boiler washing probably 15 percent of the time, or 54 days per year. Some of this is due to boiler work alone, and decrease in boiler work ought to cut this down by ten days. An engine is worth $20 a day when power is scarce, but as at times of the year engines might not be needed though available, I will estimate this saving as five days at $20 per day, or $100 per engine per year.

SUMMARY

Cost Per Engine Per Year

Soda ash, 1,700 pounds, at 1 cent per pound	$17.00
Coal wasted, 17 tons, at $2 per ton	34.00
Water wasted, 100,000 gallons, at $0.05 per 1,000	5.00
Supervision of treatment	10.00
Blowing a clinker pit	5.00
Total cost	$71.00

Saving Per Engine Per Year

Boiler repairs	$250.00
Fuel, 3 percent of $4,000	120.00
Washing boiler	40.00
Ten days' extra service at $10 per day	100.00
Total saving	$510.00
Net saving per engine per year	$439.00

The above estimate shows a net saving per engine per year of $439, and when multiplied by a large number of engines this amounts to a great deal of money. Another saving that is not estimated is the saving in delay to freight and the cost of sending out another engine and crew to haul in a train, whose engine has died on account of leaky flues.

In conclusion, it is necessary in order to prevent boiler troubles and insure getting results from water treatment to:

1. Secure best available supplies.

2. Line up enginemen and terminals to blow off boilers systematically and sufficiently to keep ahead of foaming troubles.

3. Give all waters containing sulphate hardness the necessary soda-ash treatment and provide enough chemical inspection and general supervision to keep treatment full and continuous.

Soda-ash treatment has been condemned and abandoned because of foaming troubles or failure to stop boilers leaking, and I wish to emphasize the importance of blowing off, the remedy for foaming, and of giving the treatment enough attention to keep it full and uninterrupted. If these things are done the treatment will pay large returns and will be well worth while.

A rough estimate of the horsepower of a boiler is commonly obtained by figuring that 1 horsepower is obtained from 10 square feet of heating surface.

Massachusetts Boiler Law

That the provision made for considering changes in the Massachusetts Boiler Rules twice annually was wise cannot be gainsaid. Advantage has been taken of this provision a number of times, and it has relieved many situations that were embarrassing to both the boiler manufacturers and those interested in the just enforcement of the rules. It appears from recent developments that some changes in the law itself are advisable.

The recent resignation of the chief inspector of the department developed the fact that no provision had been made for such a contingency and a successor could not be appointed; but this was a matter that affected the department alone. A more serious condition has been recently developed which affects the right of an inspector to earn his living. A company writing boiler insurance in the State of Massachusetts recently dropped that line and had its business taken over by another company, which necessitated disbanding its boiler inspection force. The company going out of business had in its employ an inspector who only a very short time before had passed an examination and secured a certificate of competency. This inspector was now out of a job, but having received the stamp of approval of the Massachusetts authorities, his services were naturally in demand, and another company engaged in the same line of business employed him.

The Massachusetts law provides that an inspector's certificate is automatically revoked when he ceases to be employed by the company that employed him at the time of making application for the certificate; so this inspector had no certificate of competency, but there appeared to be no reason why a new one could not be obtained. However, when application was made, the information was received that ninety days must elapse between two examinations to comply with the law. This is certainly a great injustice to a man who earns his living by inspection work, and we believe it will be found unconstitutional to deprive a man of his rights in such a manner. Why should not an inspector holding a certificate of competency have it transferred without further examination if he should desire to become employed by a different insurance company?

What chance has an inspector in Massachusetts to better his condition? If he seeks a more remunerative position with another company he must first forfeit the certificate of competency which he holds and stand another examination. If he should fail he would be without means of obtaining work as an inspector at all, and could not even return to his former position. Such conditions as these need prompt attention if the Massachusetts boiler laws are to continue their successful start.—*Power.*

The United States Bureau of Mines makes the statement in a bulletin just issued that the present steaming capacities of steam boilers can be tripled or quadrupled by forcing over the heating surfaces three or four times the weight of gases now passed over them. With well-designed mechanical draft apparatus, this greater weight of gases can be forced through the boilers at small operating cost. It is possible to increase the capacity of many of the present boilers in this way without reducing their efficiency much; in fact, by proper arrangement of the heating surfaces the efficiency can be made higher than the present rating. The efficiency of any boiler can be increased by arranging its heating surfaces in series with respect to the path of hot gases. New boilers of high efficiency can be constructed by making the cross-section of the gas passages small in comparison with the length, and thus forcing the gases into more intimate contact with all the heating surface.

More Geometry "Stunts" for Boiler Shop Use

BY JAMES F. HOBART, M. E.

"I want to space a sheet 12 inches wide into 21 equal spaces," said a young mechanic. "Guess that means a spacing job with the dividers, and I don't like this divider business a little bit," added the young man as he went for the tool mentioned.

"Why don't you use a bit of geometry and do that job quick and easy without any dividers?" asked the writer, who chanced to overhear the remarks above quoted.

"Geometry, nothn'! What in h—— do I want with geometry? The Old Man don't pay anything for using geometry or algebra or those dude stunts with letters and signs instead of good honest figures. Me for the dividers every time."

"That's where you're off the line, my friend. The Old Man don't pay you for using geometry because you don't know how to use it. Just you catch on; get so you can and do use it every day in the shop, and just as surely as the Old Man catches you at it just so sure will you find an extra $5 in your pay envelope every Saturday night. And you won't have to run after the O. M. to tell him about geometry, either. He will find it out mighty quick, just as he finds out each or more than either of the gentlemen. It's right square up to you, and the path to pay envelopes and checks as big as theirs leads right along beside a whole lot of 'know-how things.' Things you can't see into now, but which would be as clear as a watch crystal if you could use those mighty handy tools—geometry and algebra. For they are nothing but good tools, Bill, and there is no reason why you should shy at using them just because you don't know how. Better a good deal get to work and learn how. Say, you didn't shy or buck at the air drill or hammer, did you, the first time you were up against them? You didn't say, 'Air drill, nothin'! What in h—— do I want with the air drill'? No, not by a long shot. Why you just fell all over yourself trying to get chances to use that tool, and in less than a week you could do a pretty good job with it. Now, why do you shy at a much better pair of tools—geometry and algebra?"

"Gee! I didn't know they were tools to work with same as the air drill and hammer are."

"They surely are, Bill, and mighty good and interesting tools, too. Ones which will save as much work as is saved

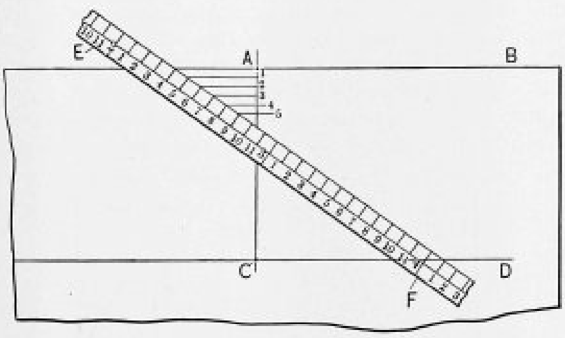


FIG. 1.—SPACING BY A DIAGONAL

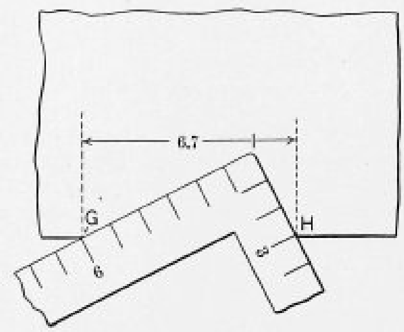


FIG. 2.—EQUAL AREA OF CIRCULAR OPENINGS

mistake the boys make and think they have covered up so the O. M. will never know anything about it."

"Huh! You'll have to 'show me.' I haven't seen any signs of the O. M. doin' any Marathon stunts with extra $5 bills! Where does he 'get on,' anyway?"

"Look a-here, Bill Small, Mr. Akerman gets more pay than Bob Roberts, don't he? and Bob gets more than Tim Messer, and Messer's envelope is fatter than yours, isn't it?"

"Sure! Mr. Akerman is chief draftsman, Roberts is foreman of the shop, Messer is a good journeyman, and I'm just a cub apprentice. Of course, Mr. Akerman gets the most pay. Gee! but I'd like to have his check every week, though."

"All right, Bill, but here is where it is right up to you whether you get Mr. Akerman's check, or one just as good, each week, or whether you rub along with a pay envelope somewhere between yours and Foreman Roberts'. It is all in how much 'geometry, algebra and dude stunts with letters and signs' that you are able to stow away in that pint of soup which you call your brains. You are as big as Mr. Akerman or Mr. Roberts, aren't you?"

"You bet! There isn't a man in the shop who can put me on my back except Tom Snyder and Mose Beasley. And I'll stand up before any of them with the gloves on!"

"Then why is it, Bill, that you don't get as much pay as Messer, Roberts, or even Mr. Akerman? There's the point, Bill. It's just because you don't know as much as either of those men. And there is not a single reason in the world why you shouldn't learn things so you will know as much by the pneumatic hammer or the sheet edge planer. So there you are, William. If you want to earn the pay—and get it, too—that comes to men like Mr. Roberts or Mr. Akerman, then you have got to learn how to use the tools they work with. Now will you be good? Will you look at geometry and algebra as you would at fine tools in the hardware window, or will you look at them as a bull looks at a red flag—want to fight it as soon as you see it?"

"No, Mr. Hobart. If geometry and algebra are just good tools for the boiler maker then I am going to know how to use them, and if I ever get a chance to butt in on a little bit of Mr. Roberts' work I'll make as stiff a bluff at it as I can."

"That's the talk, William, that's just the way to learn a thing, just go to work and learn all about it and how to use it, and then use it each and every chance you get. Then, first thing you know, along comes a chance to make good at some of Mr. Roberts' work. He may be away for a day or ill, and you can jump in and show that you can do that work as it should be done. But don't say a word that you did it. Just go right along and hunt up some more 'stunts' and learn something else you didn't know before. The 'O. M.' will get it straight that you did as good a bit of his work as he could do, and first thing you know you will be set at such work more and more, and the pay envelope will feel the effect of it mighty quick."

"I'm going to try it out, anyway. And will you tell me about that sheet spacing stunt?"

"Sure! Here it is, all drawn out in Fig. 1. The line *A C*, 12 inches long, is to be divided into 21 equal spaces. Instead of working ten minutes at spacing up and down on trial trips to get the dividers set just right, just draw lines *A B* and *C D* as shown by the engraving. Next, hunt up something with 21 equal spaces upon it, no matter how long or how short the spaces, as long as 21 of them make more than 12 inches or less than the length of lines *A B* and *C D*. A common rule or square or tape line will do the trick this time. A tape is shown at *E F*, stretched diagonally across lines *A B* and *C D*, with exactly 21 inches between those lines. See? One line shows even with 2 feet 4 inches, the other line at 4 feet 1 inch, making exactly 21 inches between the two lines."

"Yes, but how are the 21 spaces marked off?"

"Just prick along the edge of the tape in a straight line from *A B* to *C D*, then take away the tape and draw parallel lines through the prick marks as shown at 1, 2, 3, etc. If a

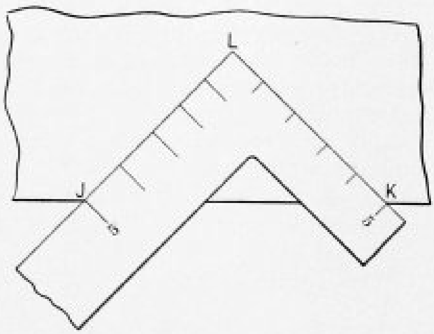


FIG. 3.—LAYING OFF 45 DEGREES

little care is taken to make the marks exactly in a straight line and fair with the marks on the tape, then the line *A C* will be found very evenly spaced into 21 equal parts."

"Well, I see that, but I don't see any geometry stunts about it. It's just plain common sense."

"That's true, William, but geometry is nothing but plain common sense, only you never thought of it that way. Now, suppose some one asked you to tell him what a 'line' is, what would you tell him? You just draw a line on a bit of sheet iron and then tell me what that line is or represents."

"Why, it's a straight mark, of course!"

"It is in this case, William, but you might have drawn a curve, and that would be some kind, too, wouldn't it? Now a 'line,' according to geometry, is something with length, but

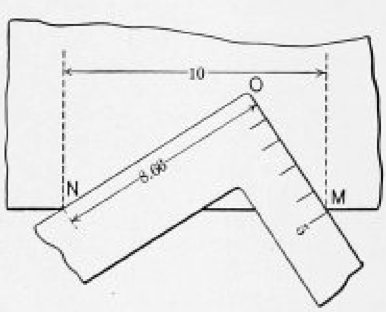


FIG. 4.—LAYING OFF 30 AND 60 DEGREES

with neither breadth or thickness. That's common sense, too, isn't it, William? You drew a 'right line' on the iron, and that is the shortest line that can be drawn between two points. And so it goes down the list, telling you what all the simple things are in a simple way, until you can understand some other things about geometry which are not so simple, but which are mighty useful in the boiler shop. And here is one right now:

"You are making a couple of penstocks in the shop; one is 3 feet in diameter, the other 6 feet. These two are to be taken from a larger penstock, which is just large enough to supply water to both the smaller tubes. What will be the diameter of the larger, or main penstock?

"To be sure this can be calculated by Mr. Roberts, Mr. Akerman or others, but we wish to know right off the reel without stopping to figure it out."

"Don't see how anything like that is to be worked out without figuring it."

"Fig. 2 is all the 'figuring' you will need for this, William. We will neglect skin friction of the water and all the other things engineers have to take account of when calculating penstocks, and we will just find one circle with an area equal to the sums of the two smaller circle areas. And the beauty of this stunt is that we won't have to monkey with areas at all, but work just with the diameters.

"Get the square, William, mark off 6 inches on the blade and 3 inches on the tongue, then lay the square as shown with the two marks just even with the edge, which must be straight. Mark the edge close to the square at *G* and *H*, then take away the square and measure the distance between marks *G* and *H*, which will be found to be 6.7, or, figuring in feet, pretty close to 6 feet 8 13/32 inches. And this is the diameter of a penstock which will supply both the 6 and 3-foot tubes."

"Gee! I don't see how that brings the right answer."

"No, William, and you can't see it or understand the reason why until you know just a little bit more about geometry. Then that and a whole lot more short cuts will be just as simple to you and just as easy as picking rivets out of a keg."

"Can I use that method, and be sure I'm right all the time, without knowing geometry? I'd like to use that 'stunt' if I could without getting 'balled up.'"

"Sure, William, go right ahead and use it every chance you get. It will be like the man with the new invention. He

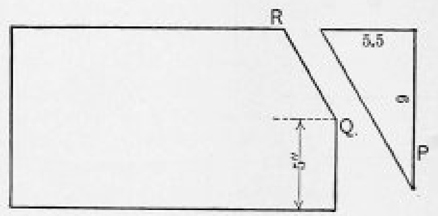


FIG. 5.—LOCATING ANGLE CUTS

wants to get it on the market as quickly as possible, so he marks each article 'patent applied for,' and the law protects him—perhaps—while he is getting his patent papers. You can go ahead, William. Imagine your new 'stunts' marked 'geometry applied for,' and use them as often as possible. And while using such things you will get your head to working and will soon find many other similar uses to which the method can be applied.

"Fig. 3 illustrates a handy variation of the area business shown by Fig. 2. In Fig. 3 it is required to lay off a simple miter, or angle of 45 degrees. All that is necessary is to lay the square on the sheet with equal figures or marks at *J* and *K*. Then mark either from *L* to *K* or from *J* to *L*, and the mark thus made will be a 'square miter,' as some workmen call it—45 degrees."

"Can you lay out any other angles that way besides 45 degrees?"

"Sure you can, William. You can lay out almost any angle in the circle. Some of them are easier than others to lay out, 45 degrees is easiest of all. Next comes 30 degrees and 60, then some others, such as 15 and 75 degrees, which are laid out by finding 45 and then laying out 30 or 60 degrees from the 45 lines, *L J* or *L K*, Fig. 3. But to lay out 30 or 60 degrees just measure a certain distance along the edge of the sheets, as 10 at *N M*, Fig. 4.

"Next take just one-half that distance, which is 5, on the square, and place that tool as shown in Fig. 4, with the 5 mark at *M* and the blade of the square just even with the 10 mark at *N*. With the square in this position strike lines from *O* to *N* and from *O* to *M*. These lines will be 30 and 60 degrees, respectively, with the edge *N M* of the sheet.

"Of course, the work of laying out may be done on a line as well as on the edge of a sheet. The latter is a little more convenient and easier to work from, that's all the difference. The laying out must be done accurately with a sharp marker, and all the lines must be placed just where they belong. Do these little things and the angles may be laid out with great exactness."

"Does geometry do all that? I thought that work belonged to the steel square instead of to geometry?"

"It belongs to geometry all right, William. It is just like this: You do some work on a job; that work was yours, and you get the credit or the blame for that work, accordingly as it was done good or poorly. But at the same time that work belongs to the shop even if you did it. Just the same with the angle-finding with a steel square. The work belongs to geometry. There are rules and reasons for it there, even if the angles were found directly by the use of the square."

"Will you show me how to find any angle? Supposing I want to lay off 23 degrees or some other odd number. Can I do that with the square or do I have to get one of those half-circles with degrees marked around it?"

"You can lay off 23 degrees with the square, William, or lay off any other angle; but, as stated, it is not as easy as laying off a few of the even-figure angles. The best way to lay off odd angles with the square is to use a table of sines. You will find such a table in any engineer's pocketbook, and the very first money you earn should be paid for a book of that kind. It is invaluable to the boiler maker or to any other mechanic. The draftsmen and engineers must have several of these books. They just can't get along without them, so it's up to you, William, to procure an 'Engineer's Pocketbook' as quickly as possible; you can get a whole lot of money out of that pocketbook, too. But if you haven't got such a book go to the nearest public library and see what they have got in that line. You will surely find a whole lot of 'dope' in the boiler line, and every bit of it will be useful for you to know while you are working up to Mr. Akerman's job.

"Now, then, to lay out the angle of 23 degrees, draw a line as before (in Fig. 4), and it is always best to make this line either 10 or 100 in length. The reason is that with 10 the fractions all read in decimals, but if we take 8, 9, 11, or some other odd number as a working line, the distances will be in all sorts of bothersome fractions, therefore take 10 or 100 for a base line, but you may take inches, halves, quarters or any other equal spaces as well as whole inches, according to the room you have to work in.

"Next, look in the table of sines, and opposite 23 degrees will be found sine .39, cosine .92. Now, if we take these numbers on the square, either 39 and 92, or 3.9 and 9.2, it makes no difference how they are doubled around in that manner if we take these figures on the square and bring them to the line or to the edge of the sheet, then a mark along one side of the square will be 23 degrees from the base line or edge, while a line along the other side of the square (one line along the blade, the other the tongue) will be just 67 degrees from the base line.

"There is another reason why it is best to make 10 as the base line. The tables of sines is made up for a base line 1 unit in length. In the table you will find the sine of 23 degrees to be .39, while the other number is .92. A base of 1 was taken for calculating the sines and cosines, so for a base of 10, which the square was used on, it is only needful to multiply the book figures by 10, or to simply move the decimal point one place to the right, making the numbers read 3.9 and 9.2. Had we been working with a base having a length of 7 then it would be necessary to multiply the book figures by 7, and this is much more of a job than multiplying by 10."

"I see how it is done, and I can do it, too. But what are 'sines' and 'cosines,' and where do they come from?"

"There is another place where you must look to geometry and trigonometry. This journal is no place in which to teach geometry. You must study that from books."

"Well, I'm sure going to get a geometry and see what I can get out of it. I may get stuck, but if other men have worked through it I don't see why I can't."

"That's the talk, William. You can do it, and you will draw larger wages as you learn more about geometry and similar things."

"Say, Mr. Hobart, sometimes cuts have to be made diagonally across a sheet, and all the blue print gives is a three-cornered figure; something as shown at *P*, Fig. 5. Now I know that to get that angle I must take 9 on the blade of the square, 5½ on the tongue, and then lay the square upon the edge of the sheet, with the 9-mark just on the edge of the sheet and 5 inches from the side, as shown at *Q*; then when I mark along the blade of the square and I get the line *Q R*, which is what is called for by the layout at *P*. But how do they find the figures in *P* after they know what angle the cut is to be?"

"They go to work, William, exactly as we did when marking off 23 degrees. They find the sine and cosine of the angle; take the figures thus found, or some larger or smaller, in the same ratio which are whole numbers or easy fractions, and put those numbers in the triangle, as shown at *P*, Fig. 5. And again you see, William, that geometry gets into about everything, in one way or another, which the boiler maker has to do with."

"Gee! It sure looks that way. Me for the geometry book!"

Area of Safety Valve

A reader has asked for information regarding the simplest way of calculating the size of a safety valve to use on a steam boiler.

The size of the safety valve must be such that the valve is capable of discharging all the steam that the boiler can evaporate when urged to its full capacity. The amount of steam that a boiler can evaporate may be estimated approximately from the grate area, the rate of combustion and the evaporation per pound of coal. The first item is fixed and the other two, though somewhat indefinite, may be estimated from the type of boiler and the conditions under which it works.

As an example, in an ordinary return tube boiler, it may be assumed that 18 pounds of coal will be burned per square foot of grate surface per hour, and that 8 pounds of water will be evaporated per pound of coal. Therefore, if these assumptions are made, in order to find the number of pounds of steam evaporated per second, multiply the grate area in square feet by 18 and multiply the product by 8, which will give the pounds of steam evaporated per hour. Divide this by 60×60, and it will give the number of pounds of steam evaporated per second.

Knowing the weight of steam to be discharged per second the size of the valve can be estimated from the following equation:

$$A = \frac{70 \times W}{p},$$

where A is the effective area of the safety valve in square inches, W is the weight of steam discharged per second (which can be found as shown above), and p is the absolute pressure of the steam in the boiler; that is, the pressure read from the gage, plus 14.7, the atmospheric pressure.

Having found the value of A from this formula, which is the effective opening of the valve, its diameter can easily be obtained.

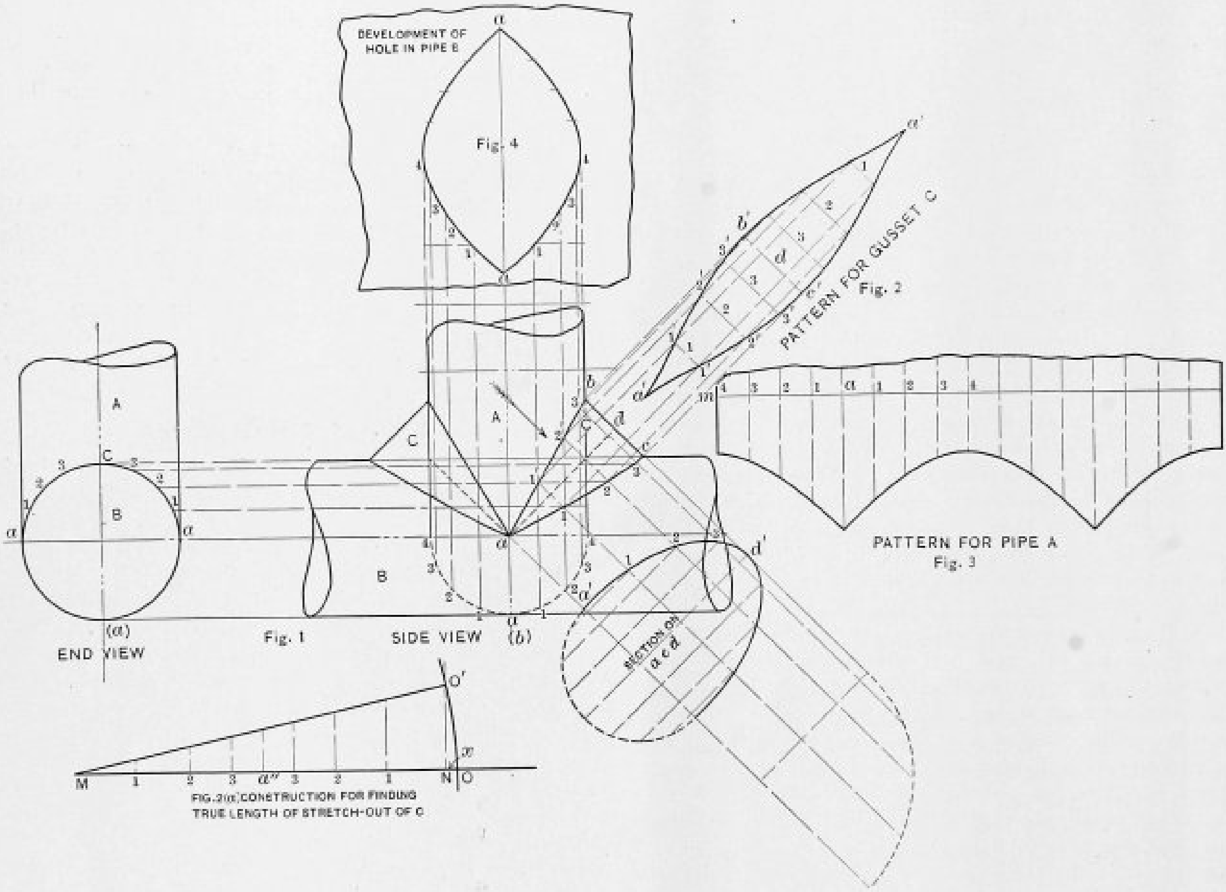
Layout of Gusset Plates

BY C. B. LINSTROM

Arrangements of this kind are used to strengthen a pipe laterally, and to prevent the entire weight of a stack from resting upon a small area of the boiler or pipe; that is, the gussets distribute the weight of the stack upon a larger area of the object to which it connects.

Figs. 1 (*a*) and (*b*) show an end and side view with the gusset *C* in position. The edge *ab* of *C* makes an angle of 60 degrees with the horizontal plane. The edge *bc* 45 degrees. Before the patterns of *C* can be laid out it is necessary to find first the line of intersection between the gusset *C* and pipe *B*. This miter line is produced by passing a number of planes through each other. Those which are passed through pipe *B* degree planes parallel to the side *bc* are then imagined to pass through the gusset *C*. These planes are not seen, but we do see each edge of the planes, which are termed traces of the planes. They are represented on the drawing by lines drawn through the elevation as 1'1, 2'2, 3'3, etc. The horizontal planes parallel to the axis of pipe *B* are then imagined to be passed through the pipe. Where the horizontal planes intersect the inclined ones determine the lines of intersection between pipe *B* and gusset *C*.

Fig. 2 shows clearly how the pattern is produced for the gussets *C*. The line *aa'* is equal to the theortical circumference around the one-half elliptical section taken on line *aed*,



DEVELOPMENT OF GUSSET PLATES JOINING PIPES INTERSECTING AT RIGHT ANGLES

are parallel to its axis, and lie in a horizontal position; those passed through the gusset *C* are parallel with its outer edge *bc*. Where these planes intersect locate the required points on the line of connection between the two objects. Before planes are passed through the gusset *C* the section at right angles to the edge *bc* is produced. This section will appear, as shown, below the side elevation when viewed in the direction of the arrow indicated on the drawing. It will be noted that section taken on line *aed* is one-half of an ellipse, the minor diameter of which is equal to the diameter of the pipe to which it connects. The one-half major axis is equal to the distance *ad* through the elevation of *C*. The one-half elliptical section is produced by drawing arcs on the respective axes. Each quadrant is then divided into the same number of equal spaces as contained in each quadrant of the circle end view; 45 plus an allowance to take care of the "take up" in rolling. Usually if light material is used no allowance is made, as in such cases the layerout would simply transfer the chord distances on section *aed* and locate them on the stretch-out line *aa'* according to their relative positions; but when heavy plate is used the chord distances cannot be used in determining the stretch-out. The length of their arcs must be found, also the required allowance for "take up" between each arc must be added. To determine the required lengths involves a construction shown in Fig. 2 (*a*), which is drawn as follows: Draw a line *M N*, and upon it set off the arc distances between the points *a*, 1, 2, 3 and *d* of the section *aed*. Erect perpendiculars therefrom, then from *N* set off a distance equal to the result of six and one-half times the thickness of plate divided by 2. In the form of a formula we have as follows:

$$\frac{6\frac{1}{2} \times t}{2} = x.$$

Where t = thickness of plate.
$6\frac{1}{2}$ = constant.
x = allowance of material to be added.

With the trammels or dividers set equal to *M O* draw the arc intersecting the perpendicular drawn from *M* at *O'*. Connect *O'* with *M*, thus completing a right-angled triangle. The distances on lines *M O'*, determined by the intersection of the perpendiculars drawn from the line *M N*, gives the required distances for laying off the stretch-out in Fig. 2. After the stretch-out line *aa'* has been drawn, draw at right angles to *bc* lines from the points *a'a*, 1'1, 2'2, etc., intersecting the perpendicular lines in the pattern. Add for laps and space off riveted holes, thus completing pattern for *C*.

The side view, Fig. 1, shows clearly how the intersection between two cylinders of equal diameters intersecting at right angles to each is produced. The miter line is straight on either side in viewing the object from the side, but in the pattern the corresponding lines are curved, in order to conform to the curved surface of the cylinder to which it joins. The miter line is indicated by the dotted line *ae*, and the pattern of the pipe is shown to the right of the elevation. Above the side view a drawing of the development of the hole in pipe *B* is shown on the flat; that is, before the pattern has been rolled up.

Failure of Locomotive Crown Sheets

The enactment of a Federal law for locomotive boiler inspection makes the subject of the causes of boiler failures of timely interest. The most complete and reliable statistics relating to locomotive boiler explosions, failures and casualties, are found in the 1910 report of the master mechanics' committee on the inspection of locomotive boilers. They cover a period of nearly five years from Jan. 1, 1905, and represent 75 percent of the locomotives of the country. When equated for the whole number of locomotives, estimated at 58,000, they will fairly represent the total number of boiler failures which are in the nature of an explosion. The equated figures show a total of 800 failures a year. It should be understood that the figures cover only those failures which resulted in personal injury or death, and the total number of failures, including those in which there was no personal injury, is still larger. Of these, five were due to explosions of boiler shells; sixty-five to explosions of fire-boxes, and 700 to damage by burning. Those due to explosion of fire-boxes and to damage by burning may be considered as crown sheet failures, since, as a rule, they are confined to the crown sheet. There are, therefore, a total of 768 failures of crown sheets per year causing personal injury, and an additional number not reported which did not result in personal injury.

The report shows that 98.3 percent of the failures were due to low water, and all of these, with the exception of 1.4 percent, were caused by the neglect of the men in immediate charge of the locomotives to maintain a proper supply of water in the boiler. The only real locomotive boiler explosions which may be charged to the weakness of the boiler are those classed as explosions of the boiler shell, and the average number per year for all the engines in the United States is 5.6, or less than 1-100 of 1 percent of the locomotive boilers in service, which is smaller than in any other service, stationary or marine.

The serious damage to locomotive boilers is, therefore, largely due to the failure of crown sheets, and, including those which do not cause injury to persons, the average number in the United States a year is now probably 1,000, or about 2 percent of the locomotives in actual service, and the number is increasing. Over 98 percent of these failures are chargeable to the engineers. Under such conditions there is little hope for any very substantial improvement by any change in boiler design, by the use of better material or by more efficient inspection. To make the boiler stronger would only increase the violence of the explosion should it occur; the practice on some roads is to use crown bolts without heads, so that when the sheet is overheated it will strip the threads and blow down before a very destructive pressure is accumulated. On other roads the front rows of crown bolts are left without heads on the fire side for the same purpose, and then only the front portion of the crown sheet is blown down when overheated. Automatic devices, either to maintain the water supply or to act as an alarm when the proper supply is not provided, have had proper consideration, but it has been determined that such devices are unreliable, and decrease the sense of responsibility of the enginemen.

When so much depends on the regulation of the water level the gage cocks and water-glass must be regarded as of prime importance, as they are the only means provided for detecting low water. Considered as safety appliances in a critical position, both of these fixtures should be used as a check on each other. The water-glass does not seem to be used to the extent one would expect, although it has been materially improved in a number of ways. It has been made more safe against breakage, and the visual indication is more distinct. The Master Mechanics' Association has frequently discussed the advisability or necessity of using the water-glass, and in 1893, in considering recommendations looking to increased safety, adopted a resolution "That the water-glass, although a convenience and an additional precaution against low water, was not absolutely necessary to safe running of locomotives." This was reaffirmed in 1900, but since that time boiler pressures have increased, the conditions of operation are more difficult, and the water-glass has been improved.

The testimony of the locomotive builders at the hearing before the House of Representatives' committee indicated that about one-half of the new locomotives are not equipped with water-glasses, showing that their use is by no means general. In its most improved form the water glass is not an expensive fixture, and would pay for itself as an additional insurance against burnt and blown crown sheets, to say nothing of the greater safety assured the enginemen. The gage cocks could be substantial fixtures, and the openings into the boiler for them, as well as for the water glasses, should be frequently inspected to prevent stoppage by mud and scale.

With such provisions and precautions the prevention of crown sheet failures, due to low water, depends entirely on the care and vigilance of the enginemen. Where their own lives are endangered, the occasional failure to maintain a proper level of water in the boiler, like the disregard of signals, may be due in rare instances to mental lapse, but as a rule it can be attributed to the men taking the chance that when the water is out of sight in the glass there may be 3 inches depth still on the crown sheet, and that the injector will soon gain on the consumption so that water will presently appear. They find by experience that in some cases the water may be low and the sheet scorched or overheated without blowing down or doing any damage, and this leads to carelessness and willingness to take risks. The failure of crown sheets is, then, as a rule, a personal matter rather than one connected with the construction of the boiler, its strength or its inspection, and the effort to reduce these failures should be directed to the cultivation of greater care and watchfulnes on the part of the enginemen.—*The Locomotive World.*

Steam boilers using oil as fuel are commonly found to have a higher efficiency than those using coal.

Superheating—Its Economy and the Design of Superheaters to Secure Adjustment and Control of Steam Temperature

The advantages of using superheated steam are generally well recognized. Certain definite savings in steam consumption result from heating steam above the temperature corresponding to the pressure, and as this saving in steam consumption is derived from only a small increase in fuel consumption a substantial net fuel saving is secured.

In an article by E. D. Dreyfus in the April, 1912, *Electric Journal*, the percent decrease in the turbine water rate, due to the use of superheated steam, is given as follows: 50 degrees superheat, 5 percent; 100 degrees superheat, 10 percent; 150 degrees superheat, 14 percent. A paper entitled "Recent Developments in Steam Turbine Practice," by K. Baumann, read before the Manchester section of the Institution of Electrical Engineers, Jan. 16, 1912, gives the following figures: 0 to 100 degrees F., 1 percent improvement on the steam consumption for every 10 degrees F.; 100 to 200 degrees superheat, 1 percent improvement of steam consumption for every 12 degrees F.

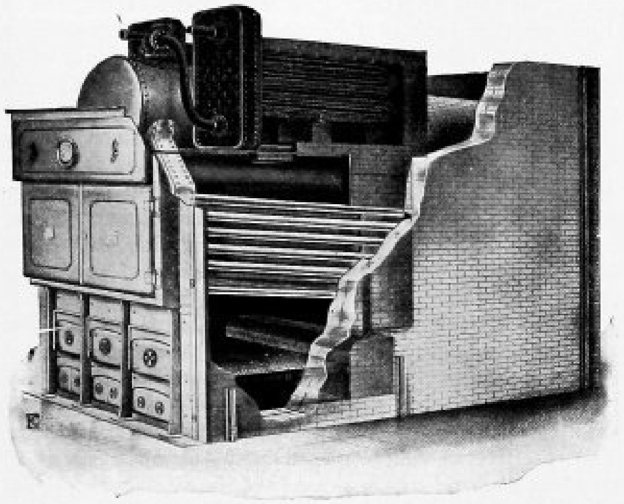


FIG. 1.—HEINE BOILER AND SUPERHEATER

This paper also brings out another important point, viz.: That the efficiency (referred to Rankine) increases considerably with increase in superheat, the following figures being given: For 100 degrees superheat, 2.5 percent better efficiency and 6.75 percent better efficiency for 200 degrees superheat.

The improvement in steam consumption and turbine efficiency given above, due to the use of superheat, is compared to the efficiency and steam consumption with dry, saturated steam. Ordinarily, however, steam supposedly dry will contain a small amount of moisture, which causes a reduction in efficiency. According to the paper referred to above the efficiency will change 1 percent for each 1 percent variation in wetness, and therefore steam consumption, measured as condensed water, will be 2 percent higher for each 1 percent increase in moisture. With reciprocating engines the presence of moisture in the steam has a still greater detrimental effect, as it greatly augments cylinder condensation. For this reason increase in economy of 12-20 percent is not uncommon with superheating only about 40-100 degrees F. (See *The Steam Engine*, by Perry.)

The saving in coal consumption, due to the use of superheated steam, is not as large as the percentage saving in steam consumption. One hundred degrees superheat will reduce the steam consumption of a turbine, say, 10 percent. This means that instead of 1 pound of water evaporated under dry and saturated conditions, only nine-tenths of a pound of water need be required if the steam be superheated 100 degrees. Assuming the feed temperature as 200 degrees, the heat absorbed in the boiler for 1 pound of steam at 150 pounds gage without superheat is 1,027 British thermal units. The heat in nine-tenths of a pound of steam under the same conditions is 924.3 British thermal units, the difference 102.7 British thermal units, being saved. To secure this saving in the amount of water evaporated, 100 degrees of superheat must be applied to each pound of steam. According to the latest steam tables this requires 57 British thermal units per pound, or 51.3 British thermal units for nine-tenths of a pound. This amount of heat, added as superheat, saves twice as much heat, 102.7 British thermal units in the boiler.

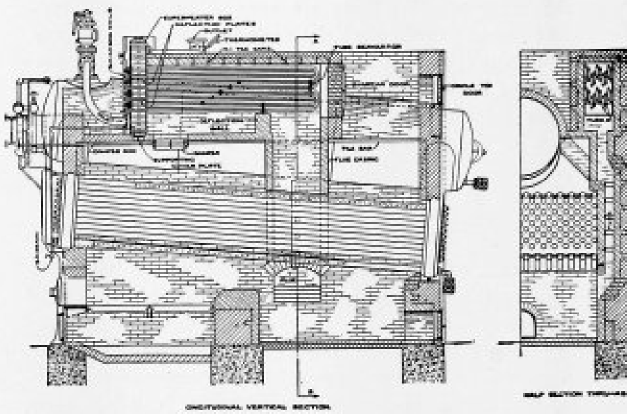


FIG. 2.—SECTIONAL DRAWINGS OF HEINE BOILER AND SUPERHEATER

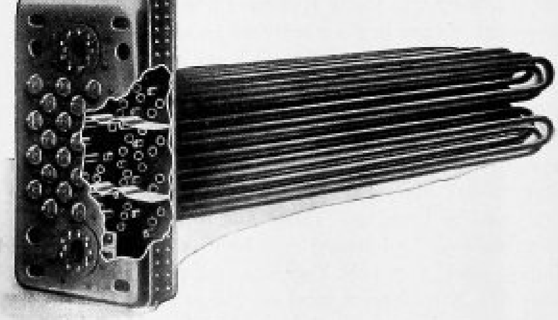
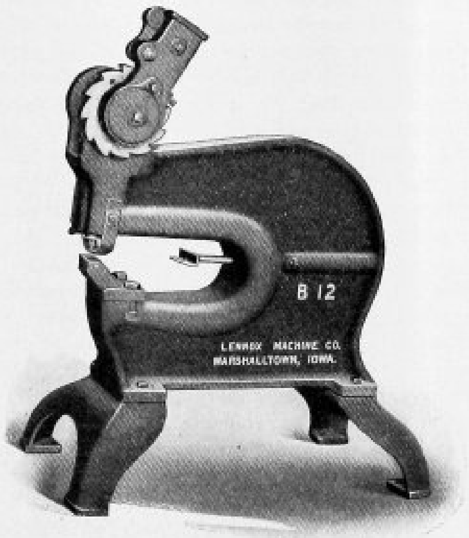


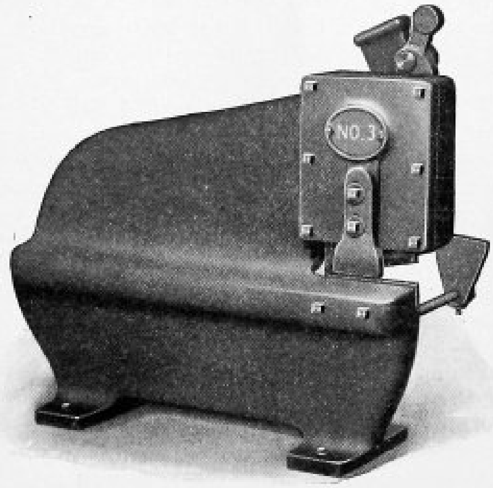
FIG. 3.—HEINE SUPERHEATER

It may therefore be said that by using superheated steam there is obtained a fuel economy equal to half the steam saving. This means that heat imparted to a superheater is just twice as valuable and generates just twice as much power as heat imparted to a boiler.

If by using superheated steam 10 or 15 percent of the output of a plant may be generated for just half the cost of the remainder of the output, it is of great importance that the superheat for which the turbine or engines are best adapted be determined by trials and then maintained continuously. The temperature of the steam should not be allowed to fall below the mean, since economy is sacrificed, and on the other

Small Punches and Shears



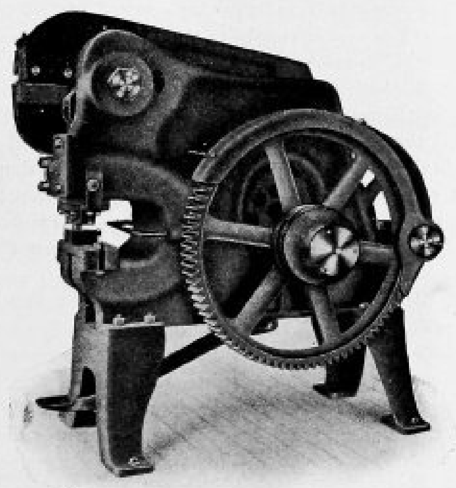


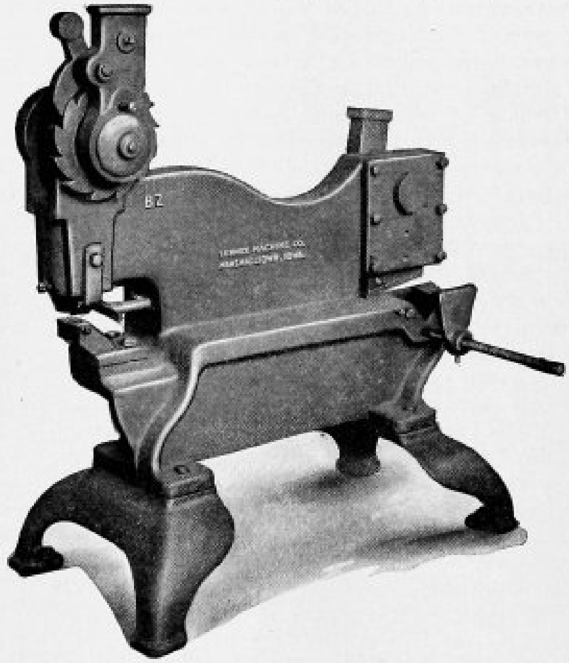
Hand Lever Splitting Shears

WE build Hand Lever Shears to handle plates from 1/8 to 1/2 inch in thickness. The frames are offset so that sheets of any width may be split. The leverage is so arranged that these machines can be easily handled by one operator.

Hand Lever Punch

THESE Punches are built in capacities ranging from 1/4 through 1/4 inch to 1 inch through 3/4 inch, or their equivalents. The throats vary in depth from 4 to 18 inches. Each machine is furnished with a stripping attachment, an improved adjustable throat gauge, a hand lever, a punch and a die.





Power Combined Punches and Shears

THESE Power Combined Punches and Shears are built with punching capacity up to 1 inch hole through 3/4 inch material, shearing up to 1 x 8 inches flats, 2 1/4 inches rounds, and 4 x 4 x 1/2 inches angles. The frame is built in one piece, making a much more rigid machine than if built in parts and bolted together.

Combined Lever Punches and Shears

THESE combined machines punch from 1/4 inch hole through 1/4 inch material to 3/8 inch hole through 3/8 inch material and shear sheets from 1/8 to 1/4 inch in thickness. The frames offset so that any width may be sheared. This machine occupies less space than the two separate machines.

NEW YORK OFFICES: HUDSON TERMINAL BUILDING 30 CHURCH ST.
EASTERN WAREHOUSES: JERSEY CITY BOONTON, N. J.

ESTABLISHED 1842 INCORPORATED 1888

JOSEPH T. RYERSON & SON

CLYDE M. CARR, PRESIDENT JOSEPH T. RYERSON, VICE-PRES.

IRON STEEL MACHINERY

CHICAGO

OFFICES: PITTSBURG CLEVELAND MILWAUKEE KANSAS CITY MINNEAPOLIS HOUSTON SEATTLE DETROIT hand temperature should not be allowed to exceed the predetermined mean, as troubles with valves, fittings and cast parts are liable to arise.

When the economy of superheating was first realized, superheats as high as 300 degrees were sometimes specified, and superheaters of a good many square feet of surface installed. It was found, however, that steam at these very high temperatures gave a great deal of trouble and caused rupture of cast iron valves and fittings. By substituting high-grade cast steel high superheats could be carried, but the added cost for these improved fitings tended to counterbalance the added returns from the use of higher steam temperatures. As a result, it has been found that the highest commercial efficiency, everything considered, is secured by the use of moderate superheat, and it has now become quite general practice to run at 125 to 150 degrees F. in turbine plants, and the same, or somewhat lower, superheat in reciprocating engine plants, where a low superheat eliminates losses from moisture and reduces cylinder condensation without causing lubricating troubles.

The temperature to which steam will be superheated depends upon the amount of steam flowing through the superheater tubes and its temperature, and, secondly, upon the amount of gas flowing over the tubes and its temperature. As the quantity of steam is controlled by the boiler load, the temperature of steam will be determined by the amount and temperature of the hot gases, which will in turn depend on the design and arrangement of boiler and superheater.

There are a number of methods of installing superheaters First we may consider that in which the superheater is placed in the path of the combustion gases after they have passed over a part of the boiler tube surface. As the first pass in the boiler absorbs as much as 80 percent of the heat in the gases, their temperature when passing over the superheater surface is comparatively low, and hence the superheater surface must be quite large. It is difficult to obtain adjustment or close regulation of superheat with this arrangement. If the volume of combustion gases and their temperature varied always in exact accordance with the amount of steam generated and passing through the superheater, the degree of superheat would be practically constant. But the amount of air used to burn a pound of coal, the temperature of the fire, and therefore the temperature of the gases after they have passed over part of the boiler surface and come in contact with the superheater surface, vary even with constant boiler load, and since the load varies with boiler pressure and the demand for steam, there are likely to be wide fluctuations in steam temperature when a superheater is installed in this manner.

Superheaters are also installed in the path of combustion gases before entering the fire tubes of a return tubular boiler; but here again the same reasons apply to explain why constant or adjustable superheat is not obtained. This also applies to superheaters installed in the gases escaping from the boiler.

It has been found, therefore, that in order to secure constant superheat it is necessary to control the volume of gases which pass over the superheater surface. A recent method is described in a paper read before the Institution of Naval Architects, March 28, 1912, by Harold E. Yarrow. Here part of the boiler surface on one side of the Yarrow boiler is replaced by superheater surface, and the combustion gases rising from the fuel bed in the center are divided between the boiler surface on one side and the boiler and superheater surface on the other. On one side there are 3,247 square feet of boiler surface, and on the other side 2,188 square feet of boiler surface and 1,265 square feet of superheater surface. A damper in the outlet of the superheater side controls the amount of gases passing over the boiler and superheater surface in this portion of the setting and controls the superheat.

Another method of installing a superheater is illustrated by the drawing of Fig. 2, which shows the Heine superheater. The superheater itself is shown in Fig. 3, and consists of a header-box, into one side of which are inserted U tubes made of 1½-inch seamless, drawn, mild steel tubing, expanded into holes provided for them. Hollow stay-bolts are used in the header, and provide means for introducing a soot blower in order to keep the exterior surfaces of the superheater tubes free from soot. The header box is divided into three compartments, so that the steam makes four passes in passing through the tube surface.

The superheater is located at the side of the shell towards the front of the boiler, and a small flue built in the side walls of the setting (see Fig. 2 section on *AB*) carries hot gas from the furnace into the superheater chamber. The gases passing up this flue come in contact with only a small part of the boiler surface and then enter the superheater chamber, making two passes over the superheater surface. According to a number of experiments, including tests at the new Grand Central heating plant in New York City, containing 6,000 horsepower of Heine boilers and superheaters, the temperature of the gases entering the superheater is about 1,500 degrees F. The average gas temperature is thus about 1,000 degrees F., and with an average steam temperature of 425 degrees the difference in temperature is 575 degrees. With superheaters installed in the path of the boiler gas the average gas temperature is in the neighborhood of 700 or 800 degrees, and the difference in temperature determining the rate of heat transmission is 275 degrees to 375 degrees. With the first arrangement higher superheats may therefore be obtained, and each square foot of superheater surface has a greater capacity.

In several respects this design is similar to an independently-fired superheater. But with the latter type control of the steam temperature can only be secured by control of combustion. The steam supply to the superheater must never fall off, or else the tubes will be overheated before combustion can be checked and the furnace cooled.

By installing the superheater, as shown in Fig. 1, it is claimed the advantages of the independently-fired superheater are obtained without the disadvantages. A damper in the outlet of the superheater setting controls the volume of hot gases used, and can shut off the flow of combustion gases entirely when no superheat is desired or when the load goes off.

It is also claimed that this arrangement makes it unnecessary to flood the superheater and avoids accumulation of mud and scale in the tubes. By setting the damper at different positions up to the full opening any desired degree of superheat may be obtained. The damper may be regulated by hand from the front of the boiler or automatically by a simple automatic damper control installed in conjunction with the superheater. With this equipment the temperature of the superheat is controlled to within 5 degrees of any desired figure.

Master Boiler Makers' Association

Meeting of Executive Board in Chicago

The executive board of the Master Boiler Makers' Association will hold a meeting at 9 A. M. Saturday, Sept. 28, at the Hotel Sherman, Chicago, Ill., for the purpose of making arrangements for the 1913 convention of the association. Mr. J. A. Doarnberger, chairman of the executive board, in announcing this meeting, earnestly requests each member of the board to make a special effort to be present, as this meeting is of great importance to the association.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

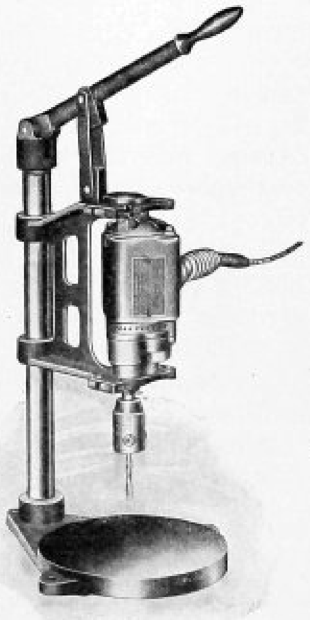
It is generally realized that the rough method of testing boilers by hydraulic pressure in excess of the safe working pressure is not only an unsatisfactory method, but that such a test gives no definite data regarding the behavior of the metal in the boiler. About the only thing it does show is that the boiler is tight and, if no rupture occurs in any part of the structure, it is assumed that the boiler is strong enough to withstand the ordinary working pressure. As a matter of fact, the stresses on the boiler under excessive hydraulic pressure may be quite different from the stresses imposed when the boiler is under steam, on account of the unequal expansion and contraction of different parts of the boiler, due to the manner in which the heat is applied. Also an excessive hydraulic pressure may set up stresses in some parts of the boiler which are beyond the elastic limit of the metal and a permanent set in the metal may result. No elastic material, such as boiler steel, has been known to fracture under stresses which are less than the elastic limit, but if stresses are set up in the metal which are beyond the elastic limit, a permanent set takes place and the material is thereby weakened. If it can be determined that under working conditions no stresses are imposed on any part of the boiler which are above the yield point of the metal, it can be assumed safely that the boiler is strong enough for working under these conditions. The point to be determined, therefore, is not how much pressure the boiler can stand without actually breaking, but how much elongation occurs in the metal under stresses imposed by the ordinary working conditions. Two methods for obtaining some information in this direction have been described in THE BOILER MAKER. One was the method of measuring by means of a delicate strain gage the actual elongation of the metal at various points in the boiler while under hydraulic test. The results of such tests made by the Bureau of Standards in Washington were given in the January number, and in the current issue a new method is described in which the cubical contents of the boiler are measured under any desired hydraulic pressure. This method shows the percentage of stretch in a boiler at definite pressures, and therefore gives a means of showing when permanent set has occurred. It does not show, however, which particular part of the boiler is affected in this way, and leaves room for some further investigation. Apparently, on the whole, the method of measuring the strain by strain gages, which can be applied at definite points in the structure, is more desirable, although either method is a distinct improvement over the ordinary method of simply applying excessive hydraulic pressure and hunting for leaks.

In discussing their experiences in the maintenance of locomotive boilers, foreman boiler makers and boiler inspectors from all over the country have widely different tales to tell. Upon analyzing such discussion, however, it will be found usually that the differences are due not so much to the use of radically different types of boiler construction as to the different conditions of service under which similar locomotives are operated, and the most disturbing factor in this respect almost invariably sifts down to the kind of water used in the boiler. It is noticeable that a railway boiler maker rarely makes a statement either at a convention or in a written paper regarding the operation of a boiler without qualifying his statement with some reference as to whether the boiler was used in a good or bad water district and what effect the water had on the boiler. Most authorities do not hesitate to state that the primary cause of boiler troubles, such as leaky flues and leaky fireboxes, is nothing more than the overheating of the metal due to the incrustation of scale formed by the impurities in the water, but in spite of the fact that this is common knowledge there seems to be in many cases slight attention given to remedies for these difficulties, and consequently the boiler maker has his hands full of repair work. In such cases we recommend a careful study of the methods of feed water treatment outlined elsewhere in this issue, for in the intelligent application of these methods lies a valuable opportunity to improve railroad locomotive service by the reduction to a minimum of engine failures due to leaky boilers and the decrease of boiler repairs.

New Improved Engineering Specialties for Boiler-Making

Sensitive Drilling Stand for Duntley Electric Drills

The Chicago Pneumatic Tool Company, Chicago, Ill., has placed on the market a sensitive drilling stand for Duntley electric drills which promises to fill a need where accurate and rapid drilling is required. The stand is strong and substantially made throughout, and is built to take standard portable drills of either the No. OOO or No. OOOX type, which are of 3/16-inch and ¼-inch capacity in metal, respectively. The drill itself is held in place by two clamping straps, shown in the illustration, secured by screws and thumb nuts. It can be removed from the stand in a few seconds and used as a portable tool.



An Automatic Ejector

The ejector illustrated is adapted to locations unhandy of access, as in the holds of vessels and other out-of-the-way places. It may be placed under the flooring alongside the keelson or in other parts of a boat where leakage is constant or intermittent. The ejector can be relied upon to start automatically when water rises beyond permissible depths. It will work when operated with either steam or water pressure, and because of this feature it may be placed any distance from the boilers, even so far that steam will condense before reaching it, as it will work with hot condensation, or it may be located any distance from a steam pump and be worked with water discharged by the sump. When operated with 40 pounds pressure (either steam or water) it will elevate 20 feet, and when operated with higher pressure it will elevate to proportionately greater heights.

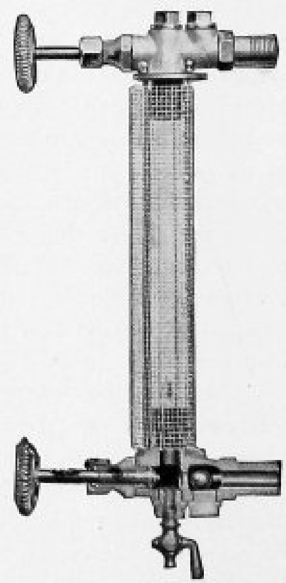
This ejector is attached to a valve and float with levers that automatically raise the spindle of the valve when leakage of water buoys up the float and lowers the spindle, closing the valve after the ejector has emptied the leakage. The valve disk is shaped so as to control the pressure that is to operate the ejector, and is made with a diameter of valve opening exactly proportionate to the length or purchase of operating levers and the surface area of the float. This arrangement allows the device to operate automatically throughout a variable range of pressure, without the use of weights or toggles that require adjustment to different pressures.

The device is manufactured by the Penberthy Injector Company, of Detroit, Mich.

Watertown Automatic Safety Water Gage

The Watertown automatic safety water gage, which is manufactured by the Watertown Specialty Company, Watertown, N. Y., is a device which it is claimed is absolutely automatic in its action in affording a positive protection from injury due to flying glass and scalding by steam and water when a water gage is broken. Between the shut-off valves and steam and water passages is a chamber containing a hard, accurately ground, bronze, non-corrosive ball, which, together with its seat, constitutes the automatic feature of the safety device. When in operation the pressure on either side of the ball chamber is equal, so that there is no force tending to hold the ball to its seat. It then falls away from the seat and lies at the bottom of the chamber, leaving the steam and water passages to the glass entirely free.

Should the glass be broken the pressure outside the valves is released and both valves are immediately raised to their seats by the internal pressure, so that the rush of steam and water through the broken glass is positively checked. After the glass is replaced and the drain cock closed, the balls will automatically release and open the gage, as the ball seat is provided with a small grove or by-pass, which allows a slight leakage of steam and water to pass it, so that the pressure on both sides of the ball is soon equalized, and they then fall from their seats, leaving the gage in its regular operating condition.



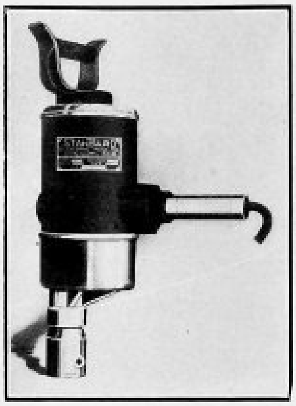
It is claimed that the ball valves cannot stick and partially close the passage, as the ball is held above the bottom of the chamber and against the valve seat by the boiler pressure, and as soon as this pressure is equalized on both sides the ball is forced by the action of gravity away from the seat, which it cannot reach again execpt by being raised by a strong pressure of steam.

Being simple in construction, it is a very easy matter to keep the gage in repair, and aside from occasionally cleaning the gage requires no attention.

High Power Electric Tools

The Standard Electric Tool Company, Cincinnati, Ohio, has developed, and is now placing on the market a line of high-power electric tools, including ball-bearing portable drills and grinders.

In the drills all gears are generated from chrome-nickel steel, case hardened, and are mounted on ball bearings packed in grease, which are claimed to be dust proof. The very



highest grade German bearings are used. The motors carry a very strong series winding, which gives them an excess of power over rated capacity, preventing overloads and burn-outs. The drills are built in 3/8-inch and 1/2-inch sizes for direct and alternating current. The 1/2-inch direct-current drill is guaranteed to ream up to 7/16 inch in thick metal. In addition a Universal drill of 3/8-inch capacity that will operate on both direct and alternating-current is made. These drills are built and recommended for the most rigorous and hardest constant service. All armatures and poles in both drills and grinders are built up of the best soft electrical sheet steel and are uniformly insulated.

The grinders are made for tool post, bench and parallel work. A special feature in connection with the tool post or center grinder is a base which converts it into a bench grinder by removing a slide and placing the motor in a groove in the top of the base, as this doubles the range of work, increasing the value of the tool in all shops, because while tool-post grinders are indispensable they are used only at intervals, and by this combination they can be kept in constant service. All motors in both drills and grinders are force-ventilated by fans of special design. The grinders are furnished with phosphor bronze bearings adjustable to wear.

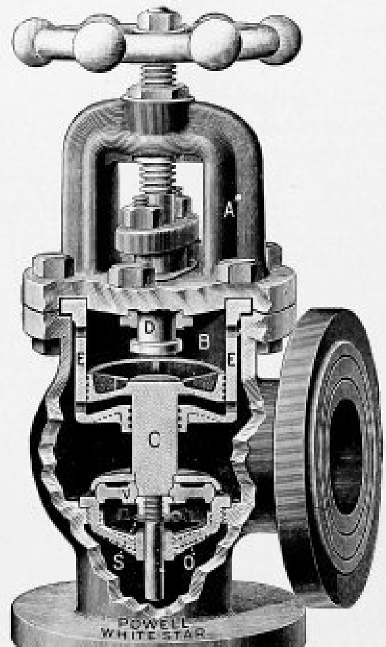
The Powell "White Star" Automatic Non-Return Boiler Valve

In steam plants where more than one boiler is in use the value of a non-return boiler valve cannot be reckoned too highly if it eliminates, as it is claimed to do, the possibility of steam escaping into a boiler which might be unexpectedly out of commission or closed off for repairs. A feature in the operation of such a valve is the prevention of danger to workmen when engaged inside a boiler for cleaning or the insertion of new tubes.

In the Powell "White Star" automatic non-return boiler valve illustrated herewith it is claimed the latest boiler laws have been carefully met; the outside screw stem and yoke top being one of the particular specifications; all parts throughout are of an extra heavy pattern and good for working steam pressures up to 250 pounds. They are made either screwed or flanged ends.

The body and yoke are cast of a close-grained iron of high tensile strength. They are connected together by steel bolts and nuts of sufficient number to firmly bind the flanged faces together. The sheet packing is housed in a recess in the body neck flange under the projecting top of the dash-pot, and is held firmly in place by the compression given by the bolts and nuts when assembled.

The disk plunger *C* (to which is attached the disk holder *R*) works in the dash-pot *E*, and they are cast of steam bronze composition. The opening in the dash-pot *E*, through which the stem of plunger *C* is guided, also the rim of the upper part



of the disk plunger, are grooved, so that these parts may work with a minimum of friction, and respond readily to any variation in the pressure. The dash-pot has four vent holes at top and bottom to allow the draining of any condensed water that may collect therein. The lift of the disk is equal to the depth of the dash-pot, insuring a full opening. The height of the lift is regulated as desired by raising or lowering the screw stem *D*.

The disk and seat are made of white "Powelium" bronze. The disk is regrindable, reversible and renewable, and is secured in the disk holder by nut *S*, which is locked in place by a cotter pin, and cannot possibly unscrew and drop off. The seat is renewable, and is cast with a guide for the lower part of the disk plunger stem, holding same perpendicular to the seat at all times. The expansion of the seat and body is uniform, the composition of the seat being made with that in view. Whenever necessary to do so the seat can be readily renewed by inserting a flat tool between the lugs projecting from the inner circle and unscrewing same.

These valves are made by The William Powell Company, of Cincinnati, Ohio.

Cumberland Electrolytic Process

The Submarine Signal Company, Boston, Mass., has secured the right to manufacture and install throughout the United States the Cumberland Electrolytic Process, which is a system for the protection of metals from corrosion, pitting, grooving and formation of scale in steam boilers, feed-water heaters, surface condensers, tanks, etc.

This process is claimed to be a natural, permanent remedy of such troubles. It is a method of electrically protecting metallic bodies wherever oxidization may take place. As oxygen is the destructive agent the Cumberland Electrolytic Process produces hydrogen on the body to be protected. This is done by the following means. An electrode of the positive sign is placed near the body affected, and a determined amount of current from the positive electrode is passed through the medium surrounding the affected body to it. As the positive electrode is destroyed it attracts the destructive oxygen gas or acids and hydrogen gas forms on the body to be protected. The amount of electricity required is extremely small and can be regulated at will, and an instrument is provided showing the amount of energy consumed and that the metallic body is at all times protected.

Electric Arc Welding

A successful electric arc welding plant consists essentially of a generator designed to maintain constant electromotive force under fluctuating load; a special rheostat, either manually or automatically controlled, depending on the operating conditions; a welding clamp of copper or iron and an assortment of welding pencils. These pencils are secret alloys, the composition and dimensions being chosen for each class of work. With these pencils the company supplies special refractory fluxes, which are applied by the user in accordance with directions, and these fluxes form the most essential part of the welding process, as upon them depend the quality of the work and the speed of operation.

Fig. 1 shows a floating plant operated by the Electric Welding Company, Produce Exchange Annex, in New York harbor.

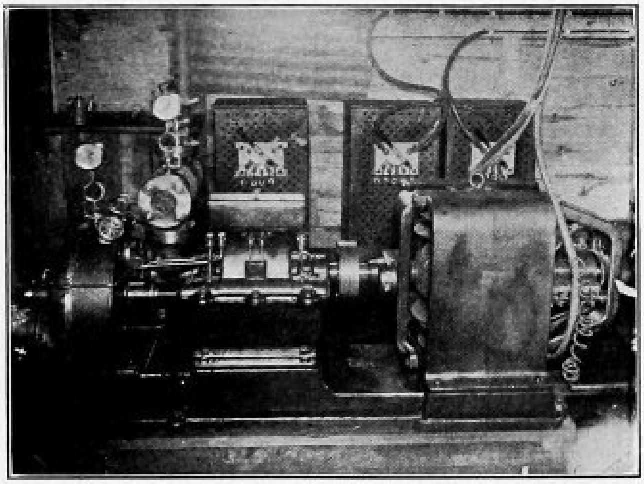


FIG. 1

The generator is driven by a De Laval steam turbine. The controlling rheostats can be seen in the background. Fig. 2 shows a welding motor-generator set installed in an industrial plant.

In making a weld the joint is prepared by chiseling the edges to a bevel. Extra thick metal is beveled from both sides toward the middle. The pieces are then placed accurately in position and new metal deposited from the welding pencil, the arc supplying the heat necessary to bring the joint to the welding temperature. The new metal is deposited in strings. With ¼-inch plates one string is sufficient. Above ¼ up to ½-inch plate three strings are necessary, as is shown in Fig. 3. A trained welder will deposit a string at the rate of 15 feet per hour.

In the repair of boilers this process has been used to weld up cracks, leaky seams, wasted rivets and patches. Weak spots are reinforced by depositing new metal on the old. In short, by means of arc welding it is claimed an old boiler can

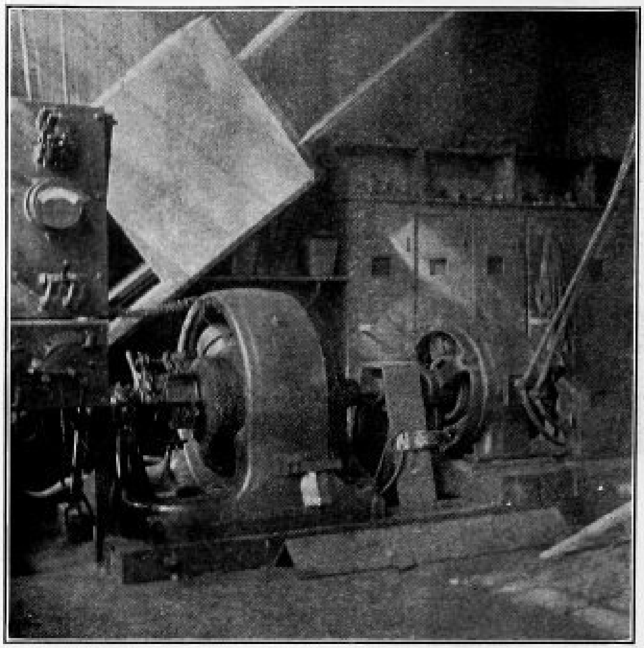


FIG. 2

be made practically as good as new. Although the use of arc welding in boiler repairs is claimed a success, yet its greatest future is claimed to be in the manufacture of boilers. First of all, it could be profitably introduced at once into boiler manufacture as a substitute for calking. A boiler with all seams welded up would be a permanent affair. However, the

FIG. 3

manufacturers of welding apparatus claim that the time will come when a boiler will be butt-welded in every seam and will be as tight as though it were blown like a glass ball. A rivetless welded boiler would be permanently tight, it would have no projecting edges to offer resistance to the flow of water and gases, and such a boiler would have a uniform thickness in all parts, and therefore troubles due to unequal heating would be minimized.

Queries and Answers

Question—Which is the hottest point under a horizontal return tubular boiler? Is it the place directly above the grates or above the bridge wall? Which is the best construction for this type of boiler—a two-ring or three-ring boiler?

Answer—The hottest point under a horizontal return tubular boiler is directly over the grates, usually at the back part of the grate near the bridge wall. The best type of construction for such a boiler is the three-ring boiler, provided the length is sufficient to use three rings.

Question—In putting a patch on a return tubular boiler over the fire-box, when it is either a quarter or half sheet, should the patch be put on the outside or inside of the shell?

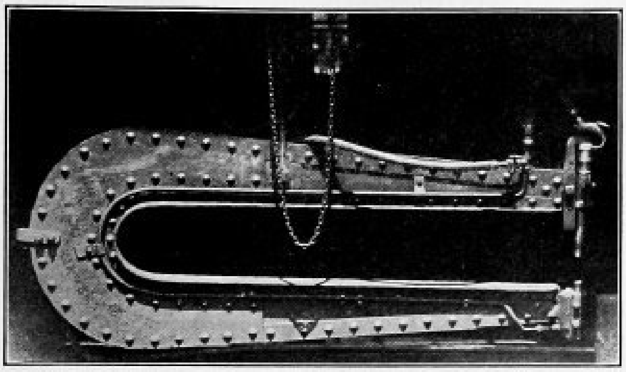
Answer—The patch should be put on the inside of the shell, and the distance from the center of the rivets to the edge of the plate should be made as small as possible.

Communications of Interest from Practical Boiler Makers

A Useful Shop Kink

The photograph shown herewith is a view of a very handy shop kink made up of a pneumatic riveting hammer and a pneumatic holder-on arranged for riveting up small boilers, air tanks, tank frames and other small work. The body is made of ⅜-inch boiler steel, and the piping and cut-out cock are plainly shown in the photograph. The hammer is adjustable to various rivet lengths and the machine has a 6-foot reach.

Another idea which we find very good is to make a short stay-bolt breaking bar for a jam riveter, with which the stay-



DEVICE FOR RIVETING SMALL TANK WORK

bolts in the throat sheet can be quickly and easily broken, either from the inside or from the pit when the mud-ring is removed. It is also useful for breaking the bolts of the back head to remove the door sheet. We have chisel bars and punches made also for the jam riveter for cutting off rivet heads and backing the rivets out on all inside work, also for cutting heads off cylinder saddle bolts and backing the bolts out, which we find to be a time and labor saver.

Piedras Negras, Coah., Mexico. B. NICHOLS.

Oxy-Acetylene Welding

For the past fourteen months I have been experimenting with the electric and oxy-acetylene welders, such as are now in use in many shops. There have been many failures with the oxy-acetylene welder when used on the straight surface of fire-box sheets in welding cracks or patches. It has been the practice in many shops to box and roll the patches to overcome the strain caused by expansion and contraction. Yet this has not been satisfactory in all cases. While experimenting and trying to bring this work to where it would always be successful, I have found a method that up to the present time has shown no failures.

I take the Swedish iron that is recommended for welding and wrap it with Russian jacket iron cut in ¼-inch strips, using about 70 percent jacket iron. You will find that after using this combination it leaves the weld with a soft ridge that is easily chipped and overcomes the expansion and contraction, so if there is another break it must be at a different point. If you have a crack on the straight sheet running from one stay-bolt to the other, such as one usually finds, remove the bolts from the crack, and with a diamond point cut the crack to a depth of ¾ inch. Run a ¼-inch ripper through, and starting from the bottom weld 6 inches, then start again at an 8-inch interval and work up. This does not leave the sheet rigid under the strain of contraction, and draws the metal gradually into place.

Build over the crack about 3/16 inch for reinforcement. In putting the bolts back have the fire-box sheets hot before driving the bolts, a heat of about 70 degrees being the most desirable. If possible have the sheets warm before making repairs, so as to have equal expansion at all points. I am now using this method, and as yet have had no failures.

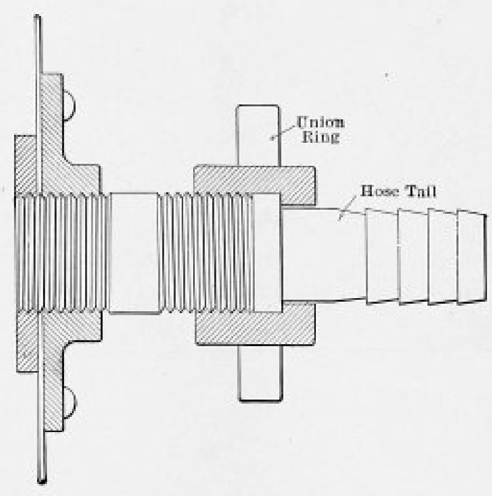
The 60,000-pound fire-box steel can be used for acetylene welding on horizontal seams where you are welding side sheets or half-door sheets. For instance, if you have a patch on the side sheet running clear down to the mud-ring you will have two vertical seams and one horizontal seam. You can weld one vertical seam and one horizontal seam with fire-box steel and Swedish iron and the jacket iron. Corner patches, or any place where the rivets are off the mud-ring, can be welded without any danger of a breakage caused by contraction or expansion.

The acetylene welding is the most difficult weld to be applied to boiler work, and there are some shops which are now operating this machine and are not getting the best results from it. I have confidence enough now, however, to know that any job on any locomotive fire-box can be welded up to produce the best results. H. A. LACERDA.

Albany, N. Y.

A Tank Fitting

A job, rather out of the usual, came into the shop the other day. This was an order for a tank 2 feet by 1 foot by 8 inches by 12 SWG, fitted in the center of one side with a coupling to take 3-inch canvas hose. The tankmaker put on the job, although a good mechanic, went rather astray over this fitting. An ordinary wrought iron 3-inch screwed pipe flange was



SECTION OF TANK FITTING

riveted in the required position. Upon receipt of the order the hose coupling was made; this consisted of the usual screw union ring and a grooved tailpiece. The ring was to be threaded to take a wrought iron barrel, the intention being to use a nipple made from the barrel; this latter, together with the union ring and tail piece, to form the fitting.

When the job was completed, ready for test, it became apparent that although a good tankmaker the mechanic doing the job throughout was a poor pipe fitter.

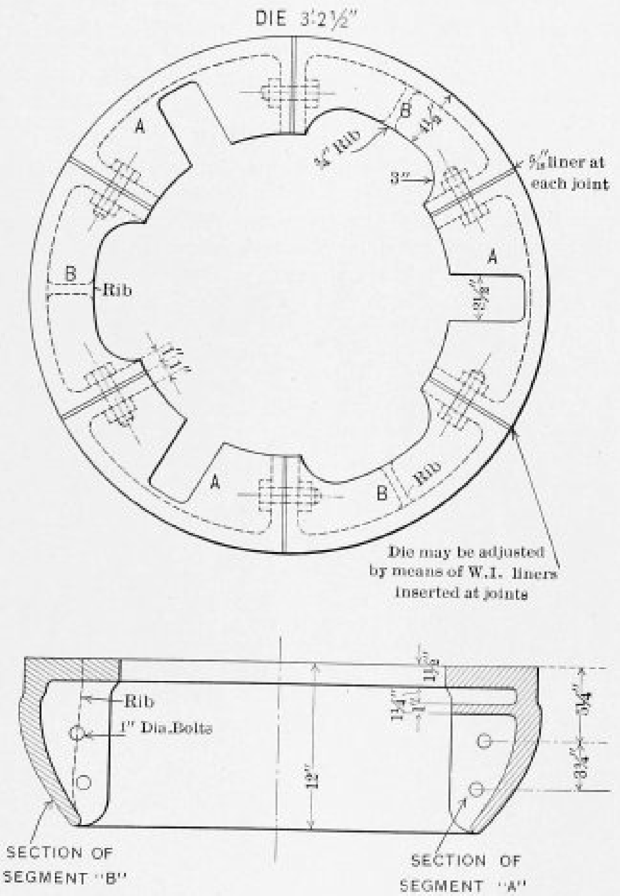
He had taken a plain piece of screwed barrel, none too good a fit, and simply screwed same home with white lead, the consequence being rather annoying, since if the union were screwed home reasonably tight, upon disconnecting, the nipple screwed out of the flange still attached to the union.

The correct method of fitting and the one adopted is shown in the sketch. A piece of barrel is screwed up from each end, leaving a small portion in the center blank. This blank center affords a grip for pipe wrench without damage to thread, while the taper at end of the threaded portion makes a tight job. The threaded part is of sufficient length on the flange end to project enough into the inside of the tank to use a lock-nut, making a rigid job, while the threaded part on the union end is of sufficient length so that the union does not seize in the taper of the thread. A. L. HAAS.

London, England.

Adjustable Die for Flanging Furnace Mouths

In the accompanying sketch are shown the general outline and sectional view of an adjustable die for flanging furnace mouths in boiler front plates. This particular die can be adjusted from 3 feet 2 inches to 3 feet 5 inches diameter by



ADJUSTABLE DIE FOR FLANGING FURNACE MOUTHS

means of wrought iron liners inserted at joints, being able thereby to flange twelve different sizes of holes, and it has been found in actual practice that the holes flanged by this die are circles true enough in shape for all practical purposes.

It is cast in six segments and then the faces of the joints are machined. A 5/16-inch liner is then inserted at each joint and the whole die bolted together. It is then turned in the lathe to 3 feet 2½ inches diameter. By taking out the liners the die can be reduced to 3 feet 2 inches diameter, and by inserting the correct thickness of liner at each joint the die can be increased to any diameter required up to at least 3 feet 5 inches without varying much from a true circle. The liners, when fitted for one die, will suit any adjustable die, provided the section is kept the same in each case. There is practically no shear on the bolts, as the die is in compression while in action.

It will be seen at once how economical this die is over the present method of using a separate die for every diameter of hole to be flanged, and also the amount of floor space saved for storing same, as one adjustable die displaces twelve ordinary single dies. JOHN CARSON.

Talks to Young Boiler Makers

In drifting around among boiler makers I have, of late, talked to the boys and find certain conditions about which I am going to say a few words, and I hope the apprentices can get the foremen to read what I say.

The foremen are growling because they can't get good boiler makers. It will be found that almost any man who has a streak of gray hair is quite sure that with him will depart the last really good boiler maker, that the breed dies with him. There are perhaps some fairly good ones left, he thinks, but they all belong to his time. Now this is not to be wondered at, it is only human nature to think just this way, but what I want to know is whether these first-rate men want the trade to die out? If not, why don't they do a little thinking and remembering, and give the boys a little better show to really learn the trade as they, the foremen, know it should be learned? Now this is a very important matter, not only for the apprentice but for the foreman and the boss. Both, I find, seem to forget that to stand by and hand tools becomes tiresome, and that heating rivets and pumping a forge wears on a boy or man. It is, of course, absolutely necessary that a boy should learn the names of the tools of the trade and their uses, and the only way to do so is to handle them; everybody who learns a trade must become so used to certain things that it will take no mental effort to remember them. A boy who after a while cannot tell the size of a rivet without measuring it better go at some other job. When we learn the multiplication table we at first have to make an effort to remember that five times five are twenty-five, but after a while it "says itself," as one might say, and a boy should not forget that to become acquainted with the names and uses of tools he must handle them until he does not have to think what is a drift or a punch. I find that when a boy is smart at heating rivets he is apt to be kept heating them until he hates the sight of a fire. I know that the foreman has to make good and get out the work or he will lose his job, but he owes something to the boys and to those who come after him, and his growl that the good boiler makers are all dying out simply means that he is assisting in making this true.

Another thing I found in the boiler shops, and that was no end of dirt. I don't mean to give the idea that I was looking for a parlor, but the dirt I refer to was absolutely unnecessary; it was on the sides of the buildings, on the floor, on the benches and tools, scraps were piled hither and yon, making it difficult to find anything, and when found it was often rusted and filthy. Now an apprentice can better this condition, and in so doing he will make his surroundings better and he will feel more self-respect. Any well-meaning apprentice should wish to have the shop he works in a better one than where the other fellow works. A boy who picks up and keeps his part of the place clean will be sure to attract attention, and that means much to him. Just to wind up this apprentice matter I want to have my friends, the foremen, do a "think act" on the subject and give the boys a chance to learn the trade and reflect credit on those in charge of them.

Now a word to the journeymen: Just give the boys a show when they are helping you. When they hold the chalk-line for you take a moment and tell them why you want it held just there, and why you put a lot of lines on the plate which to him seem useless; remember the more you teach him the better you will know the subject yourself. You can do much good by a little showing.

I was going to tell you a little about air tools, but I got off on this apprentice question. However, I will make a start, anyway.

Air is only a mechancal mixture; that is, it is made up of 21 parts of oxygen and 79 parts of nitrogen. There is a small amount of carbonic acid gas also in the air. These two gases are not chemically combined, as it is called; that is, they are mixed just as you would mix a lot of shingle nails and a lot of tenpenny nails. If the nails formed a chemical mixture we would find that the nails had disappeared and we had something in their place; thus if we bring together oxygen and hydrogen in their proper proportion we will produce water—a different thing altogether from either of the two gases.

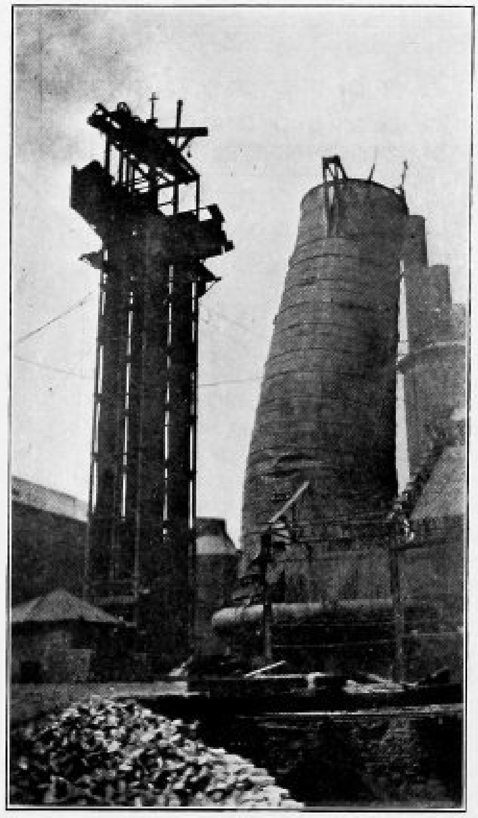
This mixture of gases which make the air has certain properties, as they are called. One is that it is very compressible. This compressibility is taken advantage of in boiler makers' tools, and we have drills and chipping hammers, etc. In compressing air it becomes heated, and when it is allowed to expand it produces cold. If it is allowed to cool it loses some of its pressure; therefore when a tank is to have 100 pounds pressure the air compressor must pump into it considerably more than 100 pounds pressure, as when the compressed air cools its volume is less, therefore the pressure drops.

An air compressor is simply a pump, which is so made as to have as little clearance as possible. In this respect air is quite different from water, which cannot be compressed to any appreciable extent, so all clearances are filled up with a non-compressible substance which it might be said produces a condition of no clearance whatever. The air being very compressible or springy would fill up any open spaces, or clearance, as it is called, and act just like a spring, thus keeping the air from coming into the cylinder, and if it cannot get in it could not be pumped out, and the piston of the air compressor would simply run back and forth, doing no compressing work, so the first point in a compressor is to have very little clearance.

When the air is compressed it will carry along with it in the pipes a certain amount of water, and this at times causes trouble. If large pipes are used less trouble will be met; but it is good practice to place tanks in the run of pipe, the size and number depending on the length of run and diameter of same. In order to use air economically to drive a tool it is found that to reheat the air accomplishes this end, but it is not practical to do this always, as in boiler makers' hand tools, but when compressed air is used to run a motor it has to be reheated, or its use cannot be made to pay; that is, if the motor is to do much and continued work. As yet in boiler shops they have not got as far as using vacuum cleaners, but that will come, as it is a very quick way of getting rid of dirt; but, of course, a vacuum is just the reverse of compressed air, which will blow out the dirt in a corner so you can swallow it easier. Now a suction or vacuum would keep the dirt out of your system and eyes. By the way, I have for years used flaxseed to take things out of my eyes. You get a few cents' worth at any drug store, and put three or four seeds in your mouth and get them wet. This makes them sort of sticky. Lift up your eyelid and put the seeds under it, and close your eye and let them stay there for some time, say ten minutes, and then let them work their way out, and the sticky substance on them gets hold of the dust or dirt in the eye and brings it out. This will not answer if the dirt is imbedded in the eye, but it will take out most things. I have often put the seed in my eye when I went to bed and found my eye all clean in the morning. F. Ormer Boy.

Collapse of a Blast Furnace

One of the blast furnaces at the plant of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala., collapsed Jan. 22, 1912, after handling an average of 251 tons of pig iron for the month. The shell was of ⅜-inch steel, 82 feet high, 24



VIEW OF COLLAPSED BLAST FURNACE

feet diameter at the base, 18 feet diameter at the top, and was leaning 7 feet 7 inches out of line. The tower was leaning in the same manner as the furnace, and was straightened by means of steel cables and turnbuckles. The furnace was dismantled and the tower straightened in sixteen days under the direction of Mr. W. T. Matthews, foreman boiler maker, and Mr. C. V. Norris, superintendent. Observer.

Patching Locomotive Fire-Box Side Sheets

About six years ago I had an article published in The Boiler Maker stating the quickest way the most successful patches could be applied on locomotive fire-boxes where the patches are exposed on the fire line, and will once more submit for your approval a method that I have followed out and which I always found to give the best results; that is, for a fire-box patch applied with plugs.

For instance, if you have a square patch on the side sheet you can put a 2-inch offset clear around the edge. Apply it with ¾-inch iron plugs, giving a 1¾-inch pitch for the holes.

Now for a lap on the water side. It should not be over ¾ inch from the center of the hole to the edge. The lap for the patch should not be over 7/8 inch from the center of the hole to the bevel of the calking edge. In applying you should apply a copper liner under the patch, extending it back from the calking edge 1/8 inch, so it will not be exposed to the fire. In applying the 3/4-inch plugs the plug should be screwed in steam-tight after the patches are properly laid up and drilled through, allowing 1/4 inch out of the sheet for riveting over.

I have made a specialty of patchwork on locomotive boiler repairing for the past fourteen years throughout the hardest

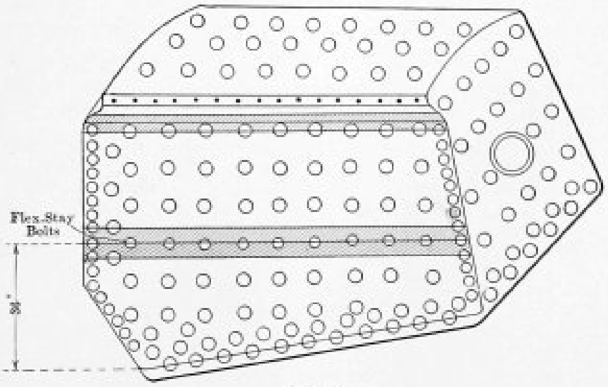


FIG. 1

water district in the country, and I find that the results of this kind of a patch have been successful enough to allow an engine to run 350,000 miles before any fire cracks or any repairs had to be made.

You will find in boxing the patch that the 2-inch offset allows water to keep the seams cool and the fire does not have any effect on the calking edge. In applying the straight patches below the fire line with patch bolts—say, for instance, you were going to apply the patch with 3/4-inch bolts—

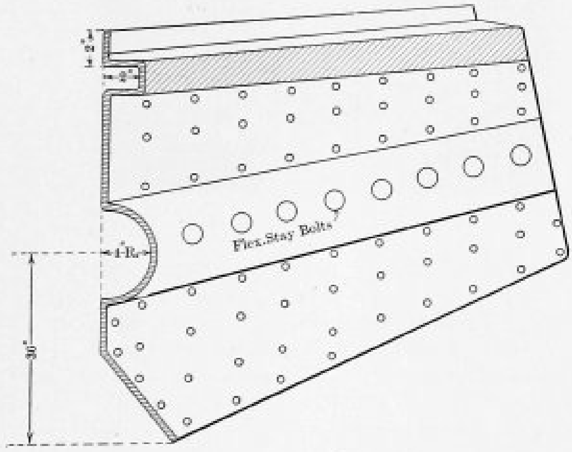


FIG. 2

the lap should be equal to the box patch for the water side and for the patch 1-inch from the center of the hole.

You will find that patchwork on locomotive fire-boxes is the most difficult repairs to be done to get the most mileage and have no failures. You will also find that 95 percent of all trouble on patchwork is because the workman allows too much lap on the patches as well as on the water side, as they think that because they have been using the same methods for years they should still do so. In some cases, also, the foreman does not take much interest in this class of repairs or the way it should be done, and it is all left to the workman who is doing the job.

I am now at present with the New York Central & Hudson River Railroad in their shops at West Albany, N. Y., as boiler inspector, and would be glad to answer any of the readers of THE BOILER MAKER or answer any question in regard to the quickest and the most successful way of applying patches on locomotive repairs.

In the accompanying sketch, Fig. 3 shows how the box patch described above is applied. Fig. 1 shows a sketch of what I have found to be the most successful side sheet that can be applied on large engines with the type of fire-box

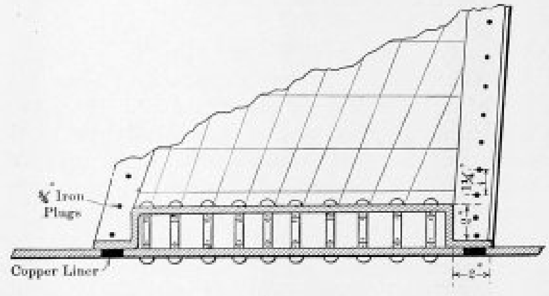


FIG. 3

shown. The jog below the seam will prevent all fire cracks from running off the rivet holes and also keeps the seam cool by throwing the fire off the seams. Fig. 2 shows an expansion corrugation to reduce the strain from the rigid stay-bolts, if there be any, with a row or two of flexible bolts through the center of the corrugation. This will also protect stay-bolt heads from burning off. H. A. LACERDA.

Albany, N. Y.

Personal

THOMAS MULVIHILL has been appointed foreman boiler maker of the Chicago, Rock Island & Pacific Railroad at Argenta, Ark.

T. A. MERRIFIELD has been appointed foreman boiler maker of the Atchison, Topeka & Santa Fe at Las Vegas, Nev., vice W. J. Doerfler, resigned.

CLARENCE C. PERRY, formerly an instructor in physics and steam engineering at the Sheffield Scientific School of Yale University, has been appointed editor of *The Locomotive*, published by the Hartford Steam Boiler Inspection & Insurance Company, of Hartford, Conn.

JOSEPH H. MCNEIL, who since 1898 has been connected with the boiler inspection service of the State of Massachusetts, first as inspector and later as chief inspector and chairman of the Board of Boiler Rules, resigned July 8 to accept the position of chief boiler inspector in the Boston department of the Hartford Steam Boiler Inspection & Insurance Company.

Information Wanted

THE BOILER MAKER is in receipt of an inquiry asking as to the whereabouts of Mr. Frank Nemarnik, a boiler maker who left Fiume, Hungary, in 1899. When last heard from in February, 1909, he was living on Sullivan street in New York. Any information which any of our readers can send us regarding Mr. Nemarnik will be forwarded to his brother, from whom the inquiry was received.

A dangerous feature of the Ohio boiler law is the discretionary power to the boiler inspectors for fixing the factors of safety to be used in determining the safe working pressure of all boilers. The lowest factor of safety allowed is four, but something besides personal discretion should be the guide in such a vital matter.

Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,028,179. BOILER CLEANER. AUGUSTUS V. BAYER, OF ST. LOUIS, MO., AND GIDEON PILLOW BROWN, OF CHICAGO, ILL.

Claim 1.—In a soot-blower for water-tube boilers having inclined tubes, a fixed riser mounted opposite the sides of the tubes, a set of pivoted nozzles communicating with the riser, arranged one above the other in vertical series and oscillating about non-coincident axes in the general direction of the tubes, thereby following the dip of the tubes during the blowing operation. Three claims.

1,028,180. SOOT-BLOWER ATTACHMENT. AUGUST V. BAYER, OF ST. LOUIS, MO., ASSIGNOR TO BAYER STEAM SOOT BLOWER COMPANY, OF ST. LOUIS, MO., A CORPORATION OF MISSOURI.

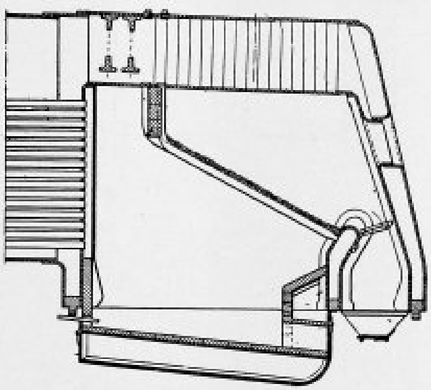
Claim 1.—In combination with a boiler-furnace wall provided with an opening, a nozzle oscillating across the opening, and projecting a cleaning fluid against the boiler, a shield passed over the nozzle, and a member overlapping the shield for maintaining the same in close proximity to the wall opposite said opening whereby the latter is kept permanently covered with the oscillations of the nozzle. Seven claims.

1,028,276. CHAIN GRATE. JOHANN RADEMACHER, OF PANKOW, NEAR BERLIN, GERMANY.

Claim 1.—In a chain-grate, the combination of a chain, a plurality of carriers secured to the chain, a plurality of detachable grate-bars carried by said carriers, and means for securing said bars to the carriers during a portion only of the travel of the chain, the grate-bars being automatically unlocked from the carriers during another portion of the travel of the chain to permit removal of the bars. Fifteen claims.

1,028,642. DOWNDRAFT FIRE-BOX. SAMUEL M. VAUCLAIN AND GEORGE R. HENDERSON, OF PHILADELPHIA, PA., ASSIGNORS TO THE BALDWIN LOCOMOTIVE WORKS, OF PHILADELPHIA, PA., A CORPORATION OF PENNSYLVANIA.

Claim 1.—The combination in a locomotive of a fire-box; a series of tubes communicating with the fire-box; a water partition extending



across the lower end of the fire-box some distance from the rear end thereof, forming a chamber, with series of inclined tubes extending from the water partition to the crown sheet of the fire-box. Five claims.

1,028,348. SMOKE AND GAS CONSUMER FOR LOCOMOTIVES. DANIEL GOFF, OF MILLVILLE, N. J., ASSIGNOR TO GOFF GRAVITY BOILER FEED COMPANY, OF CAMDEN, N. J., A CORPORATION OF NEW JERSEY.

Claim 2.—In a device, a locomotive boiler, a fire-box therefor, said fire-box comprising a plurality of horizontally disposed grate bars, a plurality of vertically disposed grate bars oppositely disposed on two sides of said fire-box, means to discharge steam from the boiler through said latter grate bars, means for discharging an auxiliary supply of steam above said grate bars, furnace doors for said fire-box, and means controlled by the movement of said furnace doors for controlling the supply of steam to said discharge means. Fifteen claims.

1,028,449. SPARK ARRESTER FOR SMOKESTACKS. ELMER E. ELLSWORTH, OF PORTLAND, ORE., ASSIGNOR TO ELLSWORTH SPARK ARRESTER COMPANY, A CORPORATION OF OREGON.

Claim.—The combination with a smokestack having a conically converging top, of a cylindrical screen clamped to the top of said stack, a reinforcing ring around the top of said cylindrical screen, a second ring concentric with and spaced around said first ring, brackets connecting the rings and supporting the outer one, a screen cap supported at its lower portion by said outer ring in spaced relation to the stack and inner screen, an outer screen band provided with reinforcing rings at top and bottom surrounding and spaced from said cap and resting on the inclined top of the stack, and pipes for disposing of the sparks caught. One claim.

1,028,450. SPARK ARRESTER. ELMER E. ELLSWORTH, OF PALMER, ORE., ASSIGNOR TO ELLSWORTH SPARK ARRESTER COMPANY, A CORPORATION OF OREGON.

Claim 1.—A spark arrester comprising an outer wire netting cylinder, binding bands secured to the upper and lower edges of said cylinder, a wire netting cylinder arranged within and spaced from said outer cylinder, an angle iron ring secured to the upper edge of said inner cylinder, a binding band secured to the lower edge thereof, radially disposed right angular bracing and supporting bars secured to said angle iron ring and to the sides of said outer cylinder, a funnel-shaped hopper secured at its upper edges to the lower ends of said supporting bars and to the lower end of said outer cylinder, means to support said arrester on a smokestack, and means to receive the spark and cinders caught by said cylinders and hopper of the arrester. Two claims.

1,028,323. SPARK ARRESTER. FREDERICK E. BREWER, OF TOWNSEND, MONT.

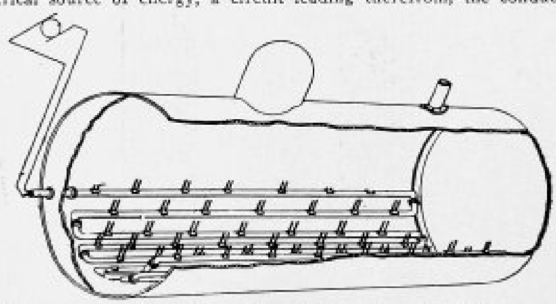
Claim.—The combination with a smokestack, of a flue supported beside the stack, a conical foraminous screen arranged within the stack, a pipe leading from the upper end of the screen and bent to extend over the stack and into the upper end of the flue, a steam-supply pipe, a branch pipe leading from the steam-supply pipe into the stack beneath the foraminous screen, a branch pipe leading from the steam-supply pipe into the upper end of the flue above the discharge end of the pipe which leads from the foraminous screen into the flue, a three-way valve arranged at the point of connection of the branch pipes with the steam-supply pipe, and means for operating the valve to place the steam-supply pipe in communication with the branch pipe, leading into the stack or into communication with the branch leading into the upper end of the flue. One claim.

1,028,902. BOILER-GRATE. JOHN L. NEWTON, OF UTICA, N. Y., ASSIGNOR TO HART & CROUSE COMPANY, OF UTICA, N. Y., A CORPORATION.

Claim 2.—In a hot-water heater having an internal fire-space with portions of the circulatory system above and below said space, a grate in said fire-space, composed of two independent sections, each section having a pipe projecting through the external wall of the heater and connected on the outside to a portion of said system below the plane of the grate and a pipe likewise projecting and connected above the plane of the grate. Five claims.

1,028,912. ELECTRIC STEAM GENERATOR. SULTAN SCHOENBROON, OF PITTSBURG, PA.

Claim 1.—An electric steam generator, having a water reservoir, a conduit within the reservoir and hermetically sealed therewithin, an electrical source of energy, a circuit leading therefrom, the conductors



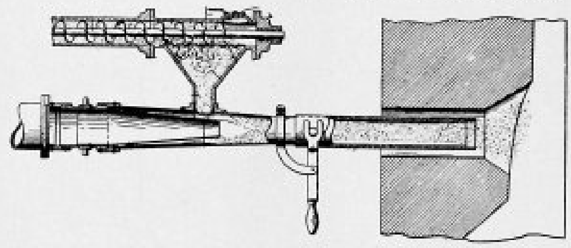
of which are mounted within said conduit, said conduit being provided with a plurality of apertures in spaced relation throughout the length thereof, and a plug carrying a pair of electrodes mounted in each aperture and connected to the conductors. Seven claims.

1,028,943. GRATE. OTTO H. KRUEGER, OF LOS ANGELES, CAL.

Claim.—In a furnace, a grate, a transverse shaft mounted underneath the grate, longitudinally disposed supporting bars extending underneath the grate, and in which the ends of the shaft are mounted for a longitudinally sliding movement, a tubular head mounted to turn on said shaft and provided with upwardly projecting tines designed to rake the grate and with a downwardly projecting arm, an actuating bar pivotally connected to said arm, means for limiting the pivotal movement of said arm relative to the bar in one direction, rods connected to said head and projecting downwardly therefrom in angular relation to the tines, and a rake carried by said rods. One claim.

1,028,997. POWDERED-FUEL-FEEDING APPARATUS. WILLIAM R. DUNN, OF EASTON, PA.

Claim 2.—Mechanism for blowing powdered coal into a combustion chamber comprising in combination an air blast conduit, a chamber provided with a port at its lower end opening to said conduit, means for



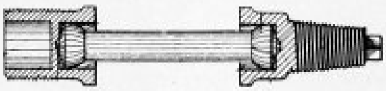
effecting a distributed feed of powdered coal into said chamber above its lower end, and provisions for supplying air to said chamber at a rate which is regulable independently of the rate at which the powdered coal is supplied thereto, and a blast nozzle extending into said blast conduit with its discharge end located in advance of said port, said blast nozzle being axially adjustable to vary the eductive effect on said chamber of the blast discharge from said nozzle. Three claims.

1,029,083. APPLIANCE FOR SMOKELESS COMBUSTION. ANDERS BORCH RECK, OF HELLERUP, DENMARK.

Claim 1.—In a combination a fire pot, a grate co-acting therewith for supporting fuel therein, a movable coking and fuel-supporting plate extending between one of the walls of said fire pot and the said grate, said plate being inclined upwardly with respect to said grate and so positioned that the upper horizontal edge thereof adjacent the wall of the fire pot is spaced therefrom to admit air into said fire pot, means for moving said plate, means for varying the air supply to the grate, and means for varying from the outside the amount of air passing through said space over the upper edge of the movable coking plate. Five claims.

1,029,104. STAY-BOLT. EDWARD W. CLARK, OF LOS ANGELES, CAL.

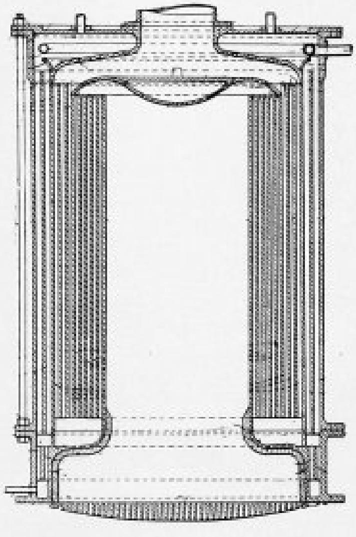
Claim 2.—An improved flexible stay-bolt, consisting of a shaft having beads; a boiler shell section comprising an exteriorly threaded thimble having a partition therein, one end of said thimble being swaged upon



one head of the shaft to revolubly connect the thimble and shaft; and a fire-box section comprising a body portion externally threaded and having in one end a socket into which is received and revolubly secured therein by swaging one head of the shaft. Three claims.

1,029,908. STEAM BOILER OR FLUID HEATER. ISRAEL BENJAMINS, OF NEW YORK, N. Y.

Claim 1.—A boiler or fluid heater having multiple passages formed in



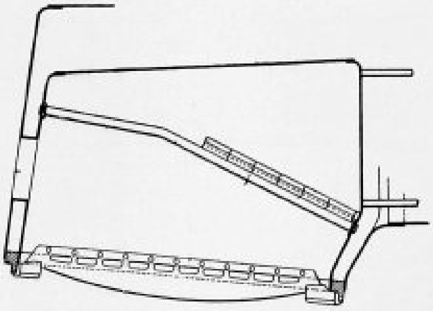
a block or casting, the said passages being adapted to act as heat-absorbing surfaces. Twenty-five claims.

1,029,680. STEAM AND AIR FEEDING DEVICE FOR FURNACES. GUSTAF A. GUSTAFSON, OF CHICAGO, ILL.

Claim 1.—In a steam and air feeding device for furnaces, the combination of steam and air pipes, leading to the combustion chamber of the furnace, a controlling valve in the steam pipe, a valve in the air pipe, a cylinder communicating with the said steam pipe, beyond said controlling valve, whereby said valve controls the steam supply to the combustion chamber, and also the steam supply to the cylinder, and a piston in the cylinder connected to the valve in the air pipe and adapted to open the same when steam pressure is admitted through said controlling valve. Three claims.

1,030,258. BAFFLE-WALL FOR LOCOMOTIVE FIRE-BOXES. HARLOW DOW SAVAGE, OF ASHLAND, KY.

Claim 1.—A locomotive fire-box comprising in combination, side plates, longitudinally inclined circulating tubes between the side plates, two side rows of brick having flat upper and lower faces, each row thereof



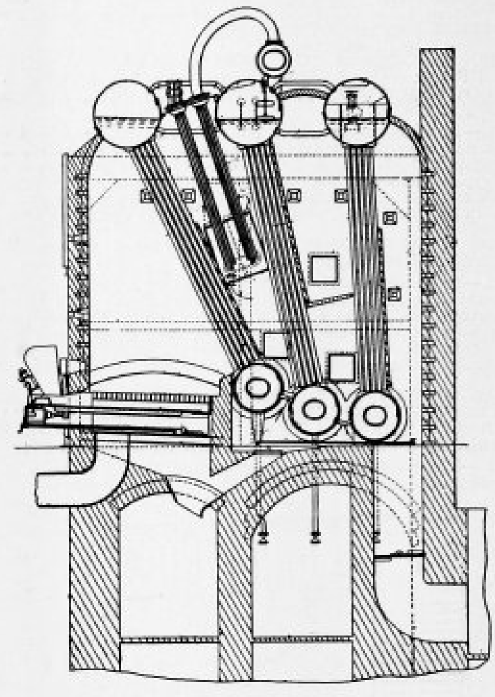
resting on two of the longitudinal tubes, and an intermediate row of brick having flat bottom faces at their ends overlapping the ends of the brick of the side rows and resting on the upper faces thereof, and having portions extending downwardly between the ends of said side brick and adapted to abut against the ends of said side brick to prevent lateral movement of said intermediate and said side brick, the brick of said side rows being adapted to be used with either flat face up. Two claims.

1,030,672. ELECTRIC HEATING SYSTEM FOR BOILERS. JAMES F. McELROY, OF ALBANY, N. Y., ASSIGNOR TO CONSOLIDATED CAR HEATING COMPANY, A CORPORATION OF WEST VIRGINIA.

Claim 1.—Means for controlling electrically heated boilers comprising an electric heating circuit, electric heaters therein, electrically operated means independent of said circuit for controlling the latter, and means operated by the level of the water for controlling said electrically operated controlling means. Thirteen claims.

1,030,218. STEAM BOILER. WILLIAM ARMSTRONG WOODESON, OF GATESHEAD, ENGLAND.

Claim 1.—In a steam boiler, water drums arranged one behind the other, the rear water drum being at a lower level than the front water drum, steam and water drums corresponding in number to said water drums and located at the top of the boiler, a furnace grate arranged in front of the foremost of said water drums, groups of straight water



tubes of equal length connecting said water drums to said steam and water drums, circulating tubes connecting the said water drums, circulating tubes connecting the said steam and water drums, a steam drum extending parallel to said steam and water drums, and tubes connecting said steam drum to one only of said steam and water drums. Four claims.

1,027,667. STEAM-BOILER FURNACE. HERMAN A. POPPENHUSEN, OF EVANSTON, AND JOSEPH HARRINGTON, OF RIVERSIDE, ILL.

Claim.—In a furnace, the combination with a combustion chamber and a grate, of a deflecting partition in said chamber embracing a plurality of horizontal, tubular, metal, water-cooled supporting members, extending transversely between and supported by the side walls of the furnace, headers by which said supporting members are connected in pairs, said headers being embedded in one side wall of the furnace and the ends of said supporting members being extended through the other side wall of the furnace, supply and return pipes located exterior to the last-named side wall of the furnace, said supply and return pipes being located respectively below and above the ends of the supporting members and being inclined in a direction from the lower rear part of the furnace to the upper forward part of the same, and connecting pipes extending from one supporting member of each pair downwardly to the supply pipe and from the other supporting members of each pair upwardly to the return pipe. One claim.

1,034,058. STEAM-BOILER. HARRY V. BRADY, OF SOUTH FRAMINGHAM, MASS., ASSIGNOR TO ROBB ENGINEERING COMPANY, LTD., OF SOUTH FRAMINGHAM, MASS.

Claim 1.—In an internally fired boiler, the combination with the boiler shell, the internal fire-box shell connecting the front and rear tube sheets and opening into a combustion chamber at the rear end, fire tubes connecting said front and rear tube sheets, a smoke box into which the tubes open at the front end of the boiler, a horizontal water and steam drum above the boiler shell, water necks connecting the proximate ends of the boiler shell and drum, and a circulating conduit extending from the front water neck down between the fire tubes and boiler shell to substantially the bottom of the boiler.—Three claims.

1,034,218.—STEAM-BOILER. HENRY L. DOUGHERTY, OF NEW YORK, N. Y.

Claim 1.—In a steam boiler, a chamber divided into forward-flow and return-flow passages for the heating gases, an upper steam-drum and a lower mud-drum each of said drums being set so as to traverse all of said passages and to lie cross-wise to the direction of flow of the heating gases through said passages and a plurality of water-tubes connecting said drums. Twenty-eight claims.

THE BOILER MAKER

OCTOBER, 1912

Laying Out Boiler Sheets with the Aid of Geometry

BY JAMES F. HOBART, M. E.

"Say, Mr. Hobart," yelled the boiler maker's apprentice, recently, "I wish you would show me how to lay out a sheet with your geometrical stunts."

"All right, John, bring on your sheet and we will lay it out."

"Here it is," said the boy, producing a sketch like Fig. 1; "the sheet is 54 inches wide, 80 inches long on one side and 86 inches on the other. The 'Old Man' wants this sheet laid out with corresponding angles equal all around, and the rivet holes spaced as near 2⅜ inches as possible. If this was a square sheet, Mr. Hobart, it would be easy to lay it out; but unless you bring out some of those geometry stunts, I don't see how we are going to get the angles and get them even."

"That is very easy, John, after you know how. The first thing we will do is to determine how far from each end of the sheet the rivets are to be spaced. Two inches, did you say? All right then, John; we will make a mark with the center punch at *A*, Fig. 1; another mark at *B*, each 2 inches from the end of the sheet, and therefore 76 inches apart. The next thing we must do will be to establish a center line. If you work by geometry you will work from the center line and not from the edge of the sheet. Now bring a straight edge, John; put one end at *A*, the other at *B*; with the punch mark *A* and *B*; then draw a line from one point to the other, using your soapstone chip, and making sure that it is well sharpened before you draw the line."

"Say, Mr. Hobart, how are you going to find the center line and get it on straight?"

"You will see, John, in a couple of minutes. Bring the trams and set them to about one-half the distance between *A* and *B*; you need not be particular about making it just 38 inches, but set the trams somewhere near the distance, and with one point at *A* strike the arc *C*; then change the trams to *B*, and strike the arc *D*. The point where these arcs cross each other at *E* is the center of the sheet. Now, just to square up this center line we will open the trams a little further, keeping one point at *B*; strike an arc at *F*; then change the tram point from *B* to *A*; strike another arc crossing the first one at *F*. Now, John, place your straight edge from *F* to *E*; run your chalk along the edge, keeping it close to the straight edge, and there you have the center line exactly square with the line *A B*. You have found this line, John, entirely by geometrical means. You have done no measuring whatever, nor have you measured any angles, or used any square, still you have got a line exactly in the center of the sheet and perfectly square with the edge from which we are working.

"The next step is easy; it is to lay out the line *I K*. All we have to do is to measure off 54 inches on the base line *A B*, measuring from *A*; place one point of the tram at *A* and the other point at the 54-inch mark, then swing the tram around and mark the arc *I*, which gives the distance of the new line from *A B*. Next move the tram to *B*, and strike arc

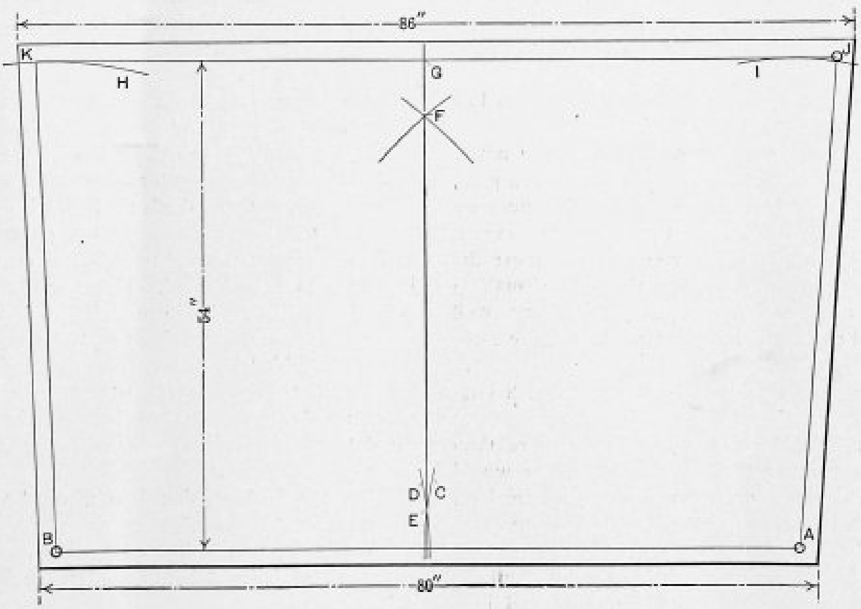


FIG. 1

H in a similar way. Place the straight edge upon these two arcs *I* and *H*, and draw the line *J K*."

"Say, Mr. Hobart, why do you use these two arcs? Why not measure right up 54 inches on the edge of the sheet at each end, then lay on the straight edge and mark across at *K* to *J*?"

"I tell you, John, we do not use that distance for the reason that we desire line *J K* to be exactly 54 inches from line *A B*. If we had measured along the oblique edge of the sheet from *A* to *I*, the distance would have been a little less than 54 inches—not much, to be true, but still there would be some difference, due to the angularity of each side, one being 38 inches and the other 41 inches long, a difference of 3 inches; but where we use the arcs *I* and *J*, John, the distances are taken right square up from *A* and 38 inches distant from the line *E F*, both at *J* and *K* as well as at *A* and *B*.

"Now, John, we will lay off the 86-inch side of the sheet, which is 82 inches between the points *J* and *K*. Let us go down to *A*, measure off 41 inches from that point, make a mark, set the tram as before, then with a point of the tram at *G*, upon the center line and also upon line *J K*, we will mark the points at *J* and at *K*; then with the straight edge draw a line *A J* and *B K*. This gives us the remaining rivet line, and we can now proceed to space the rivets, also in the geometrical way."

"Say, Mr. Hobart, why do you do all the measuring on line *A B* and work from point *A* every time?"

"We do that, John, to avoid making mistakes. You notice we measured line *A B* very carefully, and we have got a point on *E* 38 inches from *A*, and in measuring the distances we have made marks which we are pretty sure are correct. Therefore, if we do all the measuring over the line where the marks have been placed, we will not run the risk of making new mistakes in measuring out other lines. It is always well in boiler work, as well as in other measuring, to use the same base line everywhere possible."

"But, Mr. Hobart, where would we be if there was a mistake in measuring line *A B*?"

"The mistake, John, would do no more harm there than if it were made on any other line. A mistake there would queer the results, of course; but don't you see in working over line *A B* a number of times we are pretty sure to catch any mistake that has been made."

"Oh! yes, I see the idea now; we work from point *A* all the time, so that one measurement may check another and help find mistakes if there are any to be found."

"That's the idea, John, 'you are on.' Now let us get down to this rivet spacing business. What distance apart did you say the holes were to be spaced?"

"Two and three-eighth inches is called for, Mr. Hobart, by the drawing; but a note on the blue print says that we have got 1/8 inch over or under the distance to make it even."

"All right, John; how did you propose to space across line *A B* and get the rivets all even distances apart?"

"Say, Mr. Hobart, that is where I wanted to see that geometrical stunt worked. If I was going to lay out the holes I would set the dividers 2 3/8 inches, then space across the sheet from *A* to *B*, and see where I came out. Then I would open or close the dividers a little and space across again and try the thing out until the holes would come out even distances apart."

"That is a pretty sure way, John, but it is a slow one. Now we will work our geometry a little bit and see if we cannot lessen the labor of spacing across a 76-inch sheet half a dozen times. First, John, we will divide up the distance from *A* to *E* into two equal parts. Now there is a proposition in geometry that says 'Things equal to the same thing are equal to each other.'"

"Say, Mr. Hobart, what in Sam-hill has that got to do with spacing holes in a boiler sheet?"

"Just look at it this way, John; if you measure off a distance of 2 inches on a piece of iron, then measure another 2 inches in another place, you are sure that these distances are both equal to 2 inches on your rule, are you not?"

"Sure, Mr. Hobart; that would be so if I made it right."

"Then, John, you have got two things which are each equal to 2 inches on your rule, have you not?"

"Yes, that's what."

"Well, then, John, is not one of these 2 inches equal to the other 2 inches?"

"Sure, Mr. Hobart, any mutt would know that unless he was clean gone dippy."

"All right, John; now come right down to brass tacks and rivet holes in this sheet. We know pretty well that the distance *A E* equals the distance *E B*, do we not?"

"Sure, Mr. Hobart, that's right."

"Now, then, let us look at Fig. 2. Here we have *A* and *B* 76 inches apart same as in Fig. 1. We have point *E* 38 inches from either *A* or *B*, and we have to divide each of these distances *A E* and *B E*, which we know are equal. Now we want to divide them into smaller spaces of about 2 3/8 inches each."

"Sure, Mr. Hobart, that's the stunt."

"Then, John, get the small trams, set them a little more than half the distance from *A* to *E*, and draw the little arcs shown in Fig. 2 at *L* and at *M*. These arcs cross each other at a point just half-way between *A E* and *B E*. Now, John, draw a short line at these points of intersection and we have the line *A B* divided into four equal parts of 19 inches each. Do you get that, John? Here is where we have made one part equal to another part, and both of the parts are therefore equal to two other parts. Now bring on your dividers and space one of the parts, say *A* to *L*."

"Gee, Mr. Hobart, that is a whole lot easier than spacing clean across the sheet."

"Sure, John, that is just what we use geometry for, to make our work easier and better, and to enable us to do more of it."

"Well, Mr. Hobart, here are the dividers and they are set about 2 3/8 inches."

"All right, John; space across from *A* to *L* and see how you come out."

"It comes out just right."

"Yes, John, it couldn't help coming out just right, for eight times 2 3/8 happens to be just 19 inches. This makes it quite easy for spacing the holes from *A* to *B*. But in case there was a small fraction over or under eight holes you would have to space from *A* to *L* two or three times in order to get the dividers properly set, and just right here is where the geometry stunt comes in. We don't need to space any of the other three-fourths of line *A B*, because we know each of the spaces *A L*, *E M*, etc., are equal to each other, therefore eight steps of the dividers will cross any one of these spaces."

"Say, Mr. Hobart, that is a cinch; can we do the same way with the distance *J K* in Fig. 1?"

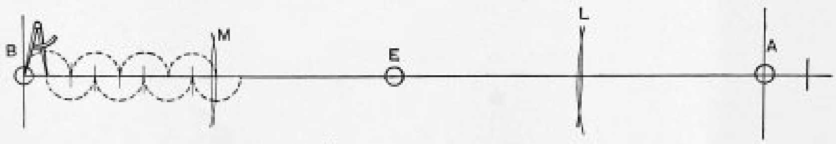


FIG. 2.—SPACING RIVET HOLES

"Sure we can, John; but in this case we have 6 inches more to space out. If you find that it is not coming out even so that you can have a hole on the center line at *G*, you had best divide the line *J K* in three or more parts of such lengths that you can bring a center upon each division point. There is more chance of making a mistake than when the spacing comes out even upon a line as it did at *A, L, E,* etc., Fig. 2."

"All right, Mr. Hobart, I would like to study that out; I believe that I can do it all right, and I guess geometry ain't no slouch after all."

"Just stick to that, John, and you will find geometry is the best tool you have got. Now, John, I want to see you lay out one of the sections of line *A B* in Fig. 2, as from *B* to *M*, and space off the eight holes. How are you going to do the stunt?"

"Why, I suppose step over there with the dividers; make a scratch at the end of each step, and then go over the line

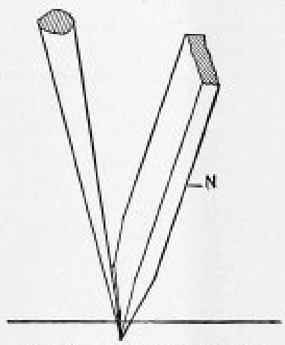


FIG. 3.—QUICK HOLE SPACING

with the center punch and bring the points in deep enough for the punch man to see."

"That is one way, John, but not the quick way, the easy way, or the labor-saving way. Let's see your soapstone? All right; sharpen it down carefully to a thin edge, just like that shown at *N*, Fig. 3. Make the bevel ¾ inch long at least, and have the edge of the tool very smooth and even. Now take the dividers in your left hand, between the thumb and two first fingers; place one point upon *B*, as shown at Fig. 2; bring the other point of the dividers upon the line running from *B* to *E*; now, without stopping an instant, and while you are swinging the dividers for another step, make a mark close against the leg of the dividers just as is shown at Fig. 3. You can do that easily and get the soapstone out of the way before the dividers have been swung out around to mark another hole on line *B M*. Continue the swinging and marking all the way from *B* to *M*, then continue from *M* to *E* and on to *A*.

"John, if you practice this method of marking you will be able to, inside of a few days, mark from *B* to *A* in less than one minute. You will find no trouble in stepping the distances apart on the line *A B*. It just takes a little care and practice in marking. If you will practice this method of marking you will be able inside of a week or two to mark around a boiler sheet in a manner which will force the 'Old Man' to work a little geometry of his own in your pay envelope."

"Say, Mr. Hobart, I am just going to practice up on this stunt; it sure is a whole lot easier than to measure off a sheet with a square and a 2-foot rule."

"All right, John, go to it. I will be over in a couple of weeks and show you another stunt which you will like as well as you like this one."

Covering for boiler settings which are good insulators and are air tight serve two useful purposes: first, to reduce the radiation of heat from the boiler to a minimum; and, second, to prevent the inrush of large amounts of cold air through a leaky setting.

Overheated Crown Sheet Caused Locomotive Boiler Explosion*

On April 4, 1912, the Southern Pacific Company reported by telegraph an accident to Oregon & California Railroad locomotive No. 2,538, operated by the Southern Pacific Company, in which the engineer and fireman were killed. An investigation of the nature and cause of this accident and the circumstances connected therewith develops the following facts:

This was a consolidated freight locomotive, operated by the Southern Pacific Company on their lines in Oregon. At the time of the explosion this locomotive was engaged in helper service on a southbound train of forty cars, weight of train 1,605 tons, drawn by road locomotive No. 3,203, with locomotives No. 2,538 and No. 2,194 coupled together between caboose and rear freight car in train. The boiler was blown clear of frames, breaking or pulling out expansion plates around firebox, shearing cylinder saddle bolts, and breaking front side of saddle; was blown over three box cars, apparently lighting on back head on an oil-tank car; rolled off to right side and landed on the bank of an 8-foot cut, a distance of approximately 218 feet from the point where the explosion occurred.

At the time of the accident the train was ascending a grade of 84.48 feet per mile, at a speed of 10 to 12 miles per hour. The accident occurred on a tangent 627 feet south of a left-hand 8-degree curve. The elevation of the right-hand rail of this curve was from 3½ to 3¾ inches for a distance of 198 feet in the center of the curve. Our inspection disclosed the fact that almost the entire crown sheet, with the exception of a portion of the left back corner, was overheated. The overheated portions of the sheet extended 4 inches below the highest part of the crown sheet at the right front corner and 1 inch below at the left front corner. At the right back corner it was about on a line with the crown sheet, while there had apparently been water on the left back corner. So far as could be ascertained by our inspection the injectors, safety valves and steam gage were in good condition. The water-glass was so located that the lowest reading was only 1 inch above the highest part of the crown sheet, as indicated by line plate on boiler head. Therefore, on an ascending grade of 84.48 feet per mile the front of the crown sheet would be uncovered with water still showing in the water-glass, and on the high side of the curve it would be, as indicated in this case, 3 or more inches below the highest portion of the crown sheet, and the glass would still show water. It was also found that other locomotives on the same division have the water-glass so located that the lowest reading is from ½ to 1 inch above highest part of crown sheet. On some of these a plate is attached to the water-glass frame in such a manner that the lower end of the glass is obscured, thus making the lowest reading 3 inches above highest part of crown sheet. The engineer who ran locomotive No. 2,538 on its previous trip into Roseburg on April 3 positively stated no such plate was attached to water-glass on this locomotive.

From statements made by engine watchmen at Drain, who watched the engine while there, it is evident that flues were leaking quite badly, as it was necessary to fill the boiler four times from 7 A. M. to 11 A. M., and that 127 gallons of fuel oil were used, whereas only 30 gallons would have been necessary had not the boiler been leaking. Seven flues were found to be plugged, which is in violation of locomotive boiler inspection rule No. 44.

We find that this accident was caused by an overheated crown sheet, due to the fact that the engine crew were evidently misled in the height of the water on account of an

* Report of the investigation, by John F. Ensign, chief inspector, of accident to Oregon & California Railroad locomotive No. 2,538, operated by the Southern Pacific Company, which occurred 4 miles south of Yoncalla, Ore., on April 4, 1912.

improperly located water-glass. We consider the local mechanical officials were at fault for permitting this locomotive to be operated with a water-glass not the proper height above crown sheet, as required by rule No. 37, and also for permitting the locomotive to be operated with flues in such a condition that it was necessary to plug a number of them in violation of rule No. 44.

Boiler Tubes Undergo a Marked Loss of Ductility

BY A CHIEF INSPECTOR

In the examination of boilers and other vessels operated under steam pressure, the inspector often meets conditions which, to him, at least, are unexpected and peculiar. But while they may be new to him, generally on conferring with other inspectors he will learn of similar instances. The present incident, with its tests showing the nature of the trouble, may be of assistance to some one in clearing up such a difficulty.

The agent for a large manufacturing concern desired an examination of one of his boilers, which were of the watertube type, and all duplicates. They had been in service but a comparatively short time. He requested this inspection not because of any trouble, but on general principles, as several months had elapsed since the last regular examination. The writer responded to this request, finding one of the boilers properly prepared for inspection. No ordinary defects were found. The boiler was clean and free from scale in all its tubes and drums. The tubes were of full thickness, and under the hammer test not the slightest indication of anything defective was conveyed to the examiner. He noted, however, a peculiar appearance to those tubes which were accessible and directly exposed to the fire. Touched with a fine file the metal was bright and its appearance was perfectly normal. The unusual color of the tubes, however, disturbed him very much, and he requested that some of them be removed for testing; since while they might prove soft and ductile he was of the opinion that they were dangerously brittle, and feared from the general arrangement of the fire-room that loss of life would follow the failure of a tube at the high pressure carried. He held this view notwithstanding the fact that these boilers were designed with a good factor of safety for the pressure carried, for he considered the danger of personal injuries greater than that of a property loss. The mill agent took up the question of testing the tubes at once. The first blow struck with a chisel in cutting off one of them close to the drum caused the tube to break. Every tube was then removed and test specimens 1 inch wide cut from each. All were found to be practically as brittle as the first, and showed an entire absence of ductility. It was felt that if they had been continued in service a shock, or even the vibrations of the engine, would have been sufficient to have fractured a tube, and the reaction might well have caused the breaking of several more.

Samples of four of these tubes were sent for chemical analysis, the result of which is given in Table 1.

Table 1.

	Percent			
	No. 1.	No. 2.	No. 3.	No. 4.
Carbon	.06	.06	.06	.06
Manganese	.02	.02	.02	.02
Phosphorus	.079	.073	.065	.073
Sulphur	.020	.026	.024	.020
Silicon	.154	.159	.143	.154

Compared with the requirements for fire-box steel boiler plate the low percentage of carbon and manganese with high phosphorus will be at once noted, and will indicate why the tubes were so deficient in ductility.

At about this same time a similar change was found to have occurred in the tube cap bolts of another type of watertube boiler, from the same maker but belonging to another firm. These bolts, which were not exposed either to the direct action of the fire or to so high a pressure as in the first case, were found by the inspector to be so brittle that on sounding them with his light hammer many of them broke as if they had been glass rods. The chemical analysis of these bolts was very similar to that of the tubes mentioned above, though differing from it to a slight extent. The conclusion is obvious that the stock in both the tubes and bolts was of a very inferior quality and ought never to have been used in any place exposed to high temperatures or to strains due to pressure.

A new tube and several bolts from the same stock as those removed were tested physically and showed good ductility, but analysis proved that the material was no better than that which had been rejected for its extreme brittleness.

It has long been a dream of the writer that all material used for boiler work should be plainly marked, the marks to be uniform with all manufacturers and to indicate the quality of the material. These could be placed upon the head of a bolt in forging at slight expense, and in welded tubes could be made at the time of welding. Solid drawn tubes present, of course, a slightly different problem, but that process itself would perhaps be a guarantee of a better quality of material than would be used for welding.—*The Locomotive.*

Piece Work

There are many things to be said concerning the advantages of piece work over day labor. With piece work a man's ability is accurately known. The men will not only apply all their skill in doing the work but they will improve their output and learn better and more efficient methods of handling their tools, so that they may work them up to greater capacity. The output can be increased and also better work turned out if the same kind of work is always given to the same man, as men constantly employed on the same kind of work will become more efficient. Cutting piece-work prices shows great ignorance and inexperience on the part of a piece-rate man. It is a sign when some men make more money on their piecework that they are taking an interest in their work and are hustling and working more efficiently. If their work is done properly they deserve all the money they can make. The chances are if another man was put at the same work he would not be able to make half as much. A man should understand that the price set on a piece of work is satisfactory to the employer, provided, of course, that it has been set properly in the first place, and that what the employer wants first of all is production. It pays the employer to treat the men with consideration and investigate their complaints, if any are made, and it may be necessary at times to raise a price to take care of certain unforeseen conditions on account of the hundreds of little things which have to be considered. If everything is given proper consideration there is no reason why the straight piece-work system should not be looked upon with favor by the employee, since through it he can make more money.—*T. F. Keane before the Master Blacksmiths' Association.*

The most effective heating surface of a Scotch marine boiler is that part included in the furnace crowns, the combustion chambers and the upper surfaces of the tubes—particularly the upper tubes. In general, the horizontal surfaces are more effective than the vertical surfaces.

American Steel Manufacturers' Revised Boiler Steel Specifications

The Association of American Steel Manufacturers has just published a revision of the well-known manufacturers' standard specifications for structural and boiler steel. The old specifications have been in force since 1895 with only minor revisions. No change has been made since 1903 until the present revision.

In connection with the new specifications printed below attention is directed to a new feature in the separation from the text of the specification of the usual schedule of allowable variations in the weight, etc., of sheared plates. This schedule, together with the tables of standard allowable variations in the size and weight of hot rolled bars, now appears under the caption of "Manufacturers' Standard Practice," as an appendix to the specifications.

Copies of the booklet containing these specifications will be furnished free on application to the secretary of the Manufacturers' Association, Jesse J. Shuman, Jones & Laughlin Steel Company, Pittsburg, Pa.

Boiler Steel

Grades

1. There shall be three grades of steel for boilers, namely, flange, fire-box and boiler rivet.

I.—Manufacture

Process

2. The steel shall be made by the open-hearth process.

II.—Chemical Properties and Tests

Chemical Composition

3. The steel shall conform to the following requirements as to chemical composition:

Elements considered.	Flange steel.	Firebox steel.	Boiler rivet steel.
Manganese, percent	0.30 to 0.60	0.30 to 0.50	0.30 to 0.50
Phosphorus, max., percent:			
Basic	0.04	0.035	0.04
Acid	0.05	0.04	0.04
Sulphur, max., percent..........	0.05	0.04	0.045

Ladle Analyses

4. To determine whether the material conforms to the requirements specified in section 3, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. A copy of this analysis shall be given to the purchaser or his representative.

Check Analyses

5. A check analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled, and this analysis shall conform to the requirements specified in section 3.

III.—Physical Properties and Tests

Tension Tests

6. The steel shall conform to the following requirements as to tensile properties:

Properties considered.	Flange steel.	Firebox steel.	Boiler rivet steel.
Tensile strength, pounds per square inch	55,000—65,000	52,000—62,000	45,000—55,000
Yield point, minimum, pounds per square inch	0.5 tens. str.	0.5 tens. str.	0.5 tens. str.
Elongation in 8 inches, minimum, percent ..	1,450,000* / tens. str.	1,450,000* / tens. str.	1,450,000 / tens. str.

Yield Point

7. The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation

8. (*a*) For plates over ¾ inch in thickness, a deduction of 0.5 from the specified percentage of elongation will be allowed for each increase of ⅛ inch in thickness above ¾ inch to a minimum of 20 percent.

(*b*) For plates under 5/16 inch in thickness a deduction of 2.5 from the percentage of elongation specified in section 6 shall be made for each decrease of 1/16 inch in thickness below 5/16 inch.

Bend Tests

9. (*a*) Cold-bend tests shall be made on the material as rolled.

(*b*) Quench-bend test specimens, before bending, shall be heated to a light cherry red as seen in the dark (about 1,200 degrees F.), and quenched in water, the temperature of which is about 80 degrees F.

(*c*) Specimens for cold-bend and quench-bend tests of flange and fire-box steel shall bend through 180 degrees without fracture on the outside of the bent portion, as follows: For material ¾ inch and under in thickness, flat on themselves; for material over ¾ inch up to 1¼ inches in thickness, around a pin the diameter of which is equal to the thickness of the specimen, and for material over 1¼ inches in thickness, around a pin the diameter of which is equal to one and one-half times the thickness of the specimen.

(*d*) Specimens for cold-bend and quench-bend tests of boiler rivet steel shall bend cold through 180 degrees flat on themselves without fracture on the outside of the bent portion.

(*e*) Bend tests may be made by pressure or by blows.

Test Specimens

10. (*a*) Tension and bend test specimens for plates shall be taken from the finished product, and shall be of the full thickness of material as rolled. Tension test specimens shall be of the form and dimensions shown in the diagram furnished with the booklet. Bend test specimens shall be 1½ inches to 2½ inches wide, and shall have the sheared edges milled or planed.

(*b*) The tension and bend test specimens for rivet bars shall be of the full-size section of material as rolled.

Number of Tests

11. (*a*) One tension, one cold-bend and one quench-bend test shall be made from each plate as rolled.

(*b*) Two tension, two cold-bend and two quench-bend tests shall be made for each melt of rivet steel.

(*c*) If any test specimen develops flaws, or if a tension test specimen breaks outside the middle third of the gage length, it may be discarded and another specimen substituted therefor.

IV.—Permissible Variations in Weight and Gage

Permissible Variations

12. (*a*) The thickness or weight of each sheared plate shall conform to the schedule of permissible variations, Manufacturers' Standard Practice, appended to these specifications.

(*b*) The dimensions of rivet bars shall conform to the Manufacturers' Standard Practice governing allowable variations in the size of hot-rolled bars, appended to these specifications.

V.—Finish

Finish

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI.—Marking

Marking

14. The melt or slab number, name of the manufacturer, grade and the minimum tensile strength for its grade as specified in section 6 shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen representing that melt or slab.

VII.—Inspection and Rejection

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. Material which, subsequent to the above tests at the mills and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, may be rejected at the shop, and shall then be replaced by the manufacturer at his own cost.

Manufacturers' Standard Practice

(*Adopted* 1896)

Permissible Variations in Sheared Plates

The thickness or weight of each sheared plate shall not vary more than the permissible variations given below:

(*a*) When ordered to weight—

For plates 12½ pounds per square foot or over:

Under 100 inches in width, 2.5 percent above or below the specified weight.

100 inches in width and over, 5 percent above or below the specified weight.

For plates under 12½ pounds per square foot:

Under 75 inches in width, 2.5 percent above or below the specified weight.

75 to 100 inches in width, 5 percent above or 3 percent below the specified weight.

100 inches in width and over, 10 percent above or 3 percent below the specified weight.

(*b*) When ordered to gage the thickness of each plate shall not vary more than 0.01 inch under that ordered.

An excess over the nominal weight corresponding to the dimensions on the order shall be allowed for each plate, if not more than that shown in the following table, 1 cubic inch of rolled steel being assumed to weigh 0.2833 pound:

Table of Allowances for Overweight for Sheared Plates When Ordered to Gage

Allowable excess (expressed as percentage nominal weight) For width of plate as follows:

Thickness ordered, inches.	Nominal weight, pound per square foot.	Under 50 inches.	50 inches to 70 inches.	70 inches and over.	Under 75 inches.	75 inches to 100 inches.	100 inches to 115 inches.	115 inches and over.
⅛ to 5/32	5.10 to 6.37	10	15	20	....	....	....	....
5/32 to 3/16	6.37 to 7.65	8.5	12.5	17	....	....	....	....
3/16 to ¼	7.65 to 10.20	7	10	15	....	....	....	....
¼	10.20	....	....	....	10	14	18	....
5/16	12.75	....	....	....	8	12	16	....
⅜	15.30	....	....	....	7	10	13	17
7/16	17.85	....	....	....	6	8	10	13
½	20.40	....	....	....	5	7	9	12
9/16	22.95	....	....	....	4.5	6.5	8.5	11
⅝	25.50	....	....	....	4	6	8	10
Over ⅝	.....	....	....	....	3.5	5	6.5	9

Allowable Variations in the Weight of Bar Sizes of Angles, Tees, Zees and Channels

(*Adopted* 1910)

For bar sizes of angles, tees, zees and channels the following average variations in weight will be permitted for sections of the various dimensions and thicknesses stated, namely:

Dimensions.	Thickness.	Variation in weight over and under.
Any dimension over 1½ inches	Over 3/16 inches	4 percent
All dimensions 1½ inches and less	Over 3/16 inches	5 percent
Any dimension over 1½ inches	3/16 inches and less	6 percent
All dimensions 1½ inches and less	3/16 inches and less	7 percent

NOTE.—A channel is in "bar" size when its greatest dimension is less than 3 inches. An angle, tee or zee is in "bar" size when its greatest dimension is less than 3 inches; or when it is 3 inches or more and at the same time the thickness is less than ¼ inch.

Allowable Variations in the Size of Hot-Rolled Bars

(*Adopted* 1910)

Rounds, Squares, Hexagons

	Variation in size. Under.	Over.
Up to and including ½ inch	0.007 inch	0.007 inch
Over ½ inch to and including 1 inch	0.010 inch	0.010 inch
Over 1 inch to and including 2 inches	1/64 inch	1/32 inch
Over 2 inches to and including 3 inches	1/32 inch	3/64 inch
Over 3 inches to and including 5 inches	1/32 inch	3/32 inch
Over 5 inches to and including 8 inches	1/16 inch	⅛ inch

Flats

Variations in thickness, under and over—Thickness of flats.

Width of Flats.	Variation in width. Under.	Over.	3/16 inches and under.	Over 3/16 inch up to ½ inch.	Over ½ inch up to 1 inch.	Over 1 inch up to 2 inches.
Up to and including 1 inch	1/64	1/32	0.006	0.008	0.010	
Over 1 inch, up to and including 2 inches	1/32	3/64	0.008	.0.012	0.015	1/32
Over 2 inches, up to and including 4 inches	3/64	1/16	0.010	0.015	0.020	1/32
Over 4 inches, up to and including 6 inches	1/16	3/32	0.010	0.015	0.020	1/32

Strength of Oxy-Acetylene Welds

The exact strength of a weld made by the oxy-acetylene process is always something of a mystery to boiler makers, and the average boiler maker is usually very cautious in subjecting an oxy-acetylene weld to excessive stresses. At the twentieth annual convention of the International Railroad Master Blacksmiths' Convention, held in Chicago last August, Mr. C. J. Fackler, of the American Car & Foundry Company, Jeffersonville, Ind., described some of the tests that he had made on the strength of oxy-acetylene welding, and the results of these tests will undoubtedly be of interest to boiler makers. The Davis-Bournonville welding system was used, and five welds were made in ⅜-inch and ⅝-inch round mild steel rods 18 inches long. These were bent on the anvil in the shape of a coil spring. The rods were given rough treatment, as it was the object to break them if it could possibly be done. There were three fractures in the ⅝-inch piece and one in the ⅜-inch piece, which were due to carelessness on the part of the welder and not on account of the system. Two pieces of 2-inch by 2-inch mild steel were welded together, and after being brought up to a high heat the piece was drawn down to one-fourth of its original size. A slight fracture was found in one corner. The piece was then bent back and forth in an attempt to break it, but no fracture occurred. Mr. Fackler, therefore, expressed his conviction that a weld can be made on 2-inch material, but that a good operator should do the work. The usual run of work which is used in the shop with which he is connected is on light stock, such as 3/16-inch plates, making welds from 6 inches to 8 feet in length. If the work is placed in the hands of an experienced welder it has repeatedly been demonstrated that reliable welds can be obtained.

Locomotive Boiler Troubles*

BY J. W. HARKOM

The substitution of steel for iron, which west of the Atlantic had practically superseded the use of copper in inside fireboxes, brought with it a beginning of boiler troubles from which the earlier types of locomotives had been almost entirely free. The cracking of side-sheets was a very serious item of expense and crippling of power; boxes would crack without any apparent cause.

The manufacture of steel plates for boiler construction was then in the experimental stage, and it was some time before it became common knowledge that the troubles arose more from chemical impurities in the metal than the actual manufacture and application of the steel plates. Many of us can remember the reputation "Otis" steel obtained as superior to all other makes, due largely to its comparative freedom from sulphur and phosphorus.

When this trouble was about understood and met, then the demand for heavier locomotives brought about increased diameter of barrel shells, which, with the introduction of coal as fuel, carried with them, in addition to the side sheet difficulties, trouble by breakage of stay-bolts. The increased diameter of the shells necessitated a swelling out of top or saddle-sheet, producing a form known as the O. G. Efforts were made to overcome breakages by increasing the size and strength of the stays, connecting the inner box with the casing or outside sheets. This did not overcome the difficulty and the writer about that period formed the conclusion that the value of a stay-bolt, which, of necessity, must possess the requisite strength to retain the two sheets in the positions desired, lay rather in flexibility than excess of strength through increased diameter and consequent stiffness.

The cause of breakage evidently was the vibratory movement of the stay-bolts, due to increase of expansion of the inside box over the outside. Repeated movement by expansion and contraction of the fireboxes caused the breakage, and as the movement of the sheet was greater at the top of box than at the bottom, the bolts at the point above referred to were subjected to a greater angle of vibration than those at the bottom, being of the same length by reason of the box being confined between the frames. The amount of vertical movement of the inside box as compared with that of the outside box or casing varied with the height of firebox and its temperature.

Fireboxes which were not confined to the width between frames were about that time built, doing away with the O. G., not only for the reason above indicated, but to give more grate area and facilitate a reduced rate of fuel combustion per square foot of grate surface, which was increased in some cases over 60 percent. This latter, particularly, was done where the smaller sizes of anthracite coal were available as cheap fuel, but carried with it other difficulties of general construction which it is not proposed to deal with here, merely remarking that boilers with tubes too close to the grates do not give good results. Some relief was afforded from the stay-bolt troubles, but it was for a very short period, as further demands for increased power, necessitating higher pressures and increased diameters of boiler shells, the O. G. stay-bolt troubles were generally as acute as ever.

Attempts have been made, and we are told with some success, to ameliorate the conditions by particular shapes and styles of stay-bolts, but the removal of the cause of the trouble has not yet to any very great extent been successfully made in general practice. As previously mentioned, stay-bolts broke where the angle of vibration was greatest, and this was taken into consideration by the writer when studying how best to meet the trouble. The conclusion come to was that if the length of stay-bolts could be increased in the same proportion as their movement with the inside box the same angle of vibration would result with the upper as with the lower stay-bolts, and the breakage would be less likely to occur. This, of course, could not be attained, but in designing some fireboxes it was made imperative that a gradual increase in length should occur with every stay-bolt as it neared the O. G., and the length at that point was made as great as compatible with the general design and conditions.

The result was very satisfactory in the reduction of failures of stay-bolts, as confirmed very recently, after over five years' service. One engine having this particular firebox, and repaired in January last, had only ten stay-bolts renewed after a year's work. The increase in water space afforded materially assisted the boilers as regards priming, the behavior of those engines being good in a bad water district.

With regard to the staying of firebox crown sheet of this boiler, by the sling stays at the front end. A criticism is offered *re* this to the effect that it is not carried far enough back, as in the writer's opinion sling stays with vertical freedom should entirely cover that part of firebox which is the first to be heated; therefore before pressure is developed that part of crown sheet is subjected to a strain which would be relieved by opportunity to expand upwards. The application of such slings at all is an admission of the correctness of the theory of such movement.

A noticeable feature of the firebox and casing is the single sheet forming the sides and crown sheet of inside box and the same for sides and saddle sheet of casing. The writer adopted this plan some years ago, and the results have been satisfactory.

To the objection offered, "What if you have to put in a new crown sheet or sides?" the answer was and is, "It is time enough to cut that sheet when you have to, and as easy to cut a clear sheet as a spliced one and a better chance to make a fresh joint."

If any careful examination of the exterior contour of a boiler is made when cold and compared with the same after steam is up an interesting study will be afforded the examiner. While considering the stay-bolt question it is offered in conjunction with the conclusion regarding flexibility that the ideal stay-bolt would be not a bolt but a chain, which would give the freedom for vibration and yet tie the two sheets together.

Another and very fruitful source of trouble is leaky tubes. The difference in longitudinal expansion of the firebox and tubes from that of the shell of the boiler to which they are rigidly connected presents a very difficult problem. The setting of tubes in tube sheets has been the subject of much experiment and careful observation, but it is fully clear that leakage occurs to tubes (when carefully set) at the firebox end only; where the expansion of the tube rearwards is met by the expansion of the firebox forwards, the results naturally being the destruction of the joint formed when the boiler was cold. The increased length of both fireboxes and tubes has greatly aggravated the trouble and when careless handling of engines without fires takes place the shrinking of tubes in their diameters at firebox end accentuate the trouble which the subsequent restoration of equal temperatures of firebox and tubes cannot overcome. This careless handling can, in the writer's view, be only partially met, but much can be done

* Abstract of a paper read before the Canadian Railway Club.

by use of substantial brick arches in firebox and the reduction of uncontrolled air admission, with the allowance of sufficient time for cooling when necessary.

The general construction of the latest types of boilers for heavy service, as illustrated in the technical journals, shows restrictions due to the large size and the necessary clearances, but the greatest change is in the flexible boiler due to the necessity for increased length to accommodate the motion of the whole vehicle over the roadbed, including switches. To successfully maintain the efficiency of locomotives of the power recently developed, the writer believes that the articulated system must be followed with each set of cylinders and their drivers operated on the same truck wheel base, as first exemplified in the *Fairlie* and lately in the *Mallet* type. That the boilers of such engines are too long to conveniently do this without being flexibly connected is apparent, and to those charged with the development of this necessity the writer gives his best wishes for success.

In the details of internal construction of boilers, the writer felt a few years ago that sufficient advantage had not then generally been taken of the improvements in forging machinery to dispense with many of the smaller members in the way of joints where upsetting of material and forging at even less expense than the older practice would reduce the number of parts and ensure better work. That this is not now true may well be, and the writer does not offer these remarks as now justified, a correction being what he would like to hear from the members.

The increase from 140 pounds pressure to 200 pounds and over, with the accompanying increase in temperatures and the increase in dimensions at all points, was undoubtedly the cause of most of the troubles in maintenance which may be in recent practice reduced chiefly to breakage of stay-bolts and leaky tubes and perhaps insufficient or incorrectly designed staying. The reversion to pressures of under 180 pounds in some recent designs proves to a certain extent the correctness of the foregoing. With such reduced pressures and the advantages accruing from the use of superheated steam, equally good results may be confidently looked for without some of the troubles attending the higher pressures.

With 63-inch drivers and 32-inch stroke, as in the case of the *Mikado* above referred to, a fairly high efficiency as regards fuel may be reasonably expected, provided the power is not wasted by high speed and light trains. The introduction of superheating on locomotives, when not carried too far, cannot injure their boiler structure, and tends to fuel economy.

An interesting feature in development of modern boilers is the disappearance of the old wagon top and flat sides. The only modern approach to it is the *Belpaire,* and many have been the tribulations attending them before the advent of flanging presses of sufficient size and power to successfully form the corners, which, as intimated above, gave so much trouble. The desire to provide storage for dry steam was the reason offered for these types of construction, but superheating has obviated that necessity.

The writer advocates the use of a steel casting covering the whole surface to be stayed, thus eliminating the use of a doubling plate as frequently practiced. On this casting the attachments for stays project, and when the casting is made, say ¾ inch thick, the flat surface is better reinforced, with better opportunities for riveting and clearances for mountings. The facing of the side of casting next to face plate gives a true surface and prevents any distortion of the face plate.

The writer recently saw in a technical journal that a locomotive engineer of repute had said it was better to make a narrow butt-strap for a joint than a wide one, by making the narrow strap thicker to gain the strength of joint needed. Excess of stiffness anywhere in a boiler is undesirable. Too wide a joint and too many rivets are certainly objectionable, but that designer is respectfully referred to the rules for joints as promulgated by the British Board of Trade for marine service, which, when intelligently followed, give the highest efficiency, and are applicable to all boilers, and scientifically correct.

Some time ago the writer was consulted as to a boiler for which certain inspectors had on examination of the drawings reduced the intended working pressure. The builders thought they had done just about all they could to get what they wanted, but on examination of the drawings the writer found there were too many rivets in the joint and that by leaving out half those on the outer rows of the joint (a butt-strap design) the pressure should be, and was later, allowed.

The recent issue by our railway commissioners of regulations for inspection and testing of locomotive boilers do not entail a very great amount of additional work or responsibility, outside the clerical work of reports, on Canadian railways. The record of those railways in general is good, and that good record doubtless due to their conscientious efforts to secure efficiency and safety. Some little points of indefiniteness as regards location of responsibility occur which should be cleared up, as if any attempt is made to place responsibility it should be made clear in a thoroughly practical manner. It also seems to the writer that by the number of reports and their frequency the Commission is taking on itself too much responsibility for regulating the conduct of the railways in detail. If not promptly and invariably followed up where violations of instructions are apparent, and check inspections made, the result will be a worse state than before. Heavier penalties for failure involving risk or actual damage to life and property would seem likely to be more efficient.

The Deflector Sheet

The importance of an exact adjustment of the deflector or diaphragm sheet in the smoke-box has induced extensive experiments to be made in order to fix a reliable standard that could readily be applied to any size or class of locomotive. In this work the committees of the Master Mechanics' Association have contributed much that is of real value in the proper adjustment of smoke-box appliances. A fundamental necessity is the exact alinement of the smoke-stack and exhaust pipe, after which the deflector sheet should be so constructed as to extend at least half-way over the face of the flues, and to the deflector there should be attached a movable apron or double sheet, as it is almost invariably found that the exact height of the deflector or distance from the bottom of the smoke-box to the lower edge of the deflector sheet is a matter of experimental adjustment.

The chief factor in the proper fitting of the deflector sheet is the condition of the fire. If the fire burns particularly hard at the front of the fire-box, it shows conclusively that the movable apron is too low and that there is a sharp draft passing through the lower flues. On close examination it will be found that the upper flues will become choked more rapidly than in the lower section. In moving the adjustment apron it may be stated that it is better to make the change a very small one and carefully note the effect. The evenness of the condition of the fire in burning is the end which must be attained by all properly adjusted smoke-box attachments.

It may be readily observed that there is a tendency in the construction and repair departments of many railroad shops to fix certain specific dimensions in the location of deflector sheets—the space from the bottom of the smoke arch and distance from the flue sheet being set down as absolute in certain classes of locomotives. This is a gross error, and the fact has been repeatedly demonstrated that various kinds of fuel, and even climatic conditions, materially affect the steaming qualities of locomotives. In addition to this it need hardly be stated that the kind of road itself and the traffic conditions are of material consequence, as well as the varying amount of the loads to be moved by the locomotives. All affect the draft upon the fire, and render the proper adjustment of the deflector sheet a more or less constant and delicate cause of care to the engineer who is desirous of obtaining the best results from the locomotive in his charge.

An interesting volume could be filled with illustrations of devices that have been tried in smoke-boxes with a view to meet the problem of equable firing and good steaming. We believe that what is known as the Master Mechanics' smoke-box comes nearest to meet all the requirements of the situation, but it appears that the perfect appliance is not yet in hand, as many complaints from correspondents come to us. It has been suggested that a contrivance that could readily move the lower edge of the deflector sheet without necessitating the opening of the smoke-box door would be a step in the right direction.—*Railway and Locomotive Engineer.*

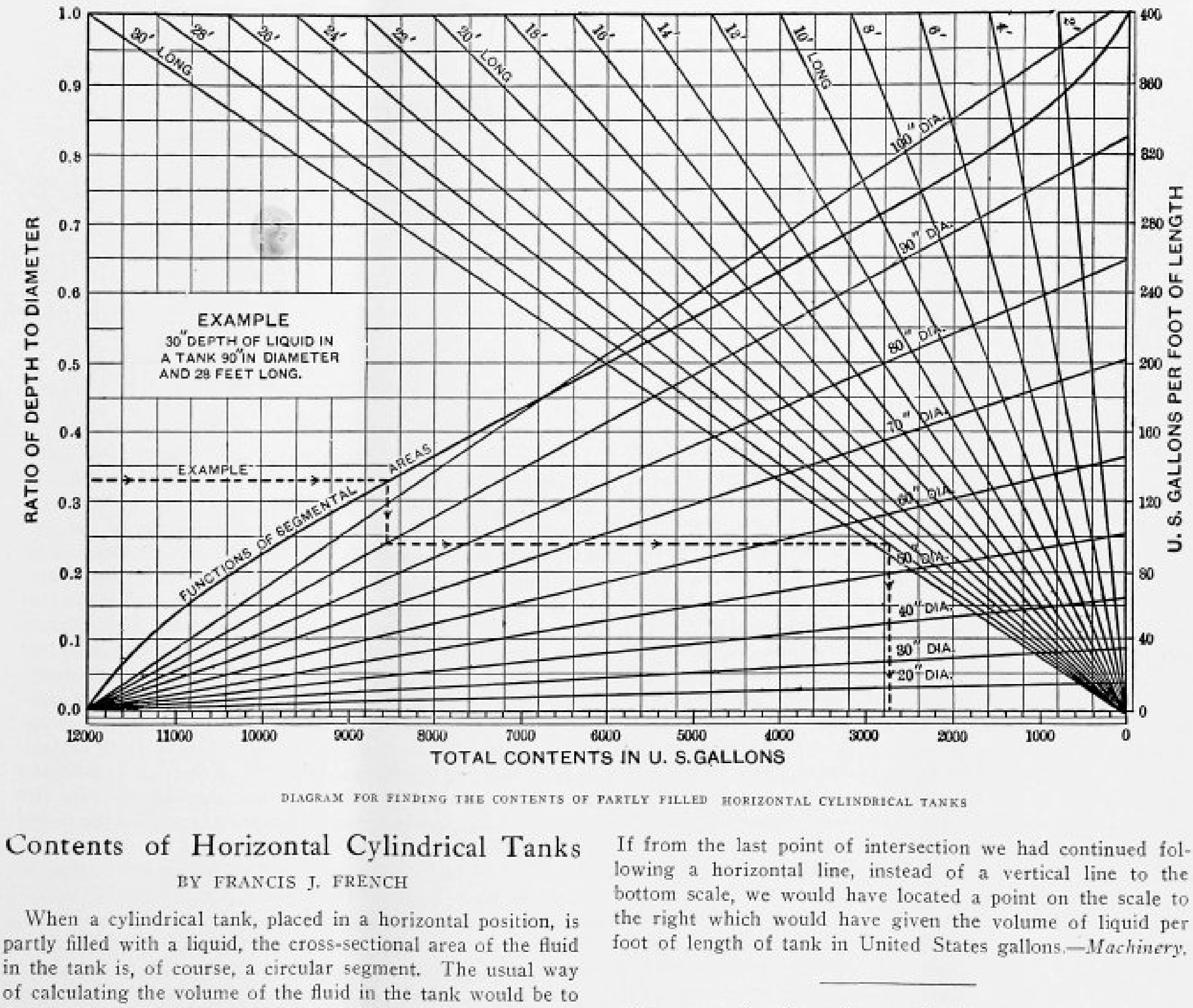


DIAGRAM FOR FINDING THE CONTENTS OF PARTLY FILLED HORIZONTAL CYLINDRICAL TANKS

Contents of Horizontal Cylindrical Tanks

BY FRANCIS J. FRENCH

When a cylindrical tank, placed in a horizontal position, is partly filled with a liquid, the cross-sectional area of the fluid in the tank is, of course, a circular segment. The usual way of calculating the volume of the fluid in the tank would be to find the area of this segment and multiply this area by the length of the tank. In this way the volume of the fluid would be found in cubic feet or cubic inches, according to the unit of measurement used. This expression, then, would usually have to be converted into gallons.

A rapid approximate method is provided by the accompanying diagram, the use of which is illustrated by an example in dotted lines. The scale on the left-hand side of the diagram gives the ratio of the depth of the fluid in the tank to the total diameter. The diagonal lines on the diagram give, respectively, the diameter of the tank and the total length. The scale on the right-hand side of the diagram gives the volume of the contents in United States gallons per foot of length, while the scale at the bottom of the diagram gives the total contents of fluid in the tank.

As an example, let us assume that the liquid fills the tank to a depth of 30 inches, that the total diameter of the tank is 90 inches, and that it is 28 feet long. The ratio of depth to diameter is then one-third, and, beginning at this point on the scale to the left, we follow a horizontal line until it intersects the line marked "functions of segmental areas." From this line we follow a vertical line until it intersects the line denoting the diameter of the tank, and then again a horizontal line until it intersects the line for the total length of the tank; from this point we follow a vertical line to the bottom scale which gives the volume of the liquid in United States gallons.

If from the last point of intersection we had continued following a horizontal line, instead of a vertical line to the bottom scale, we would have located a point on the scale to the right which would have given the volume of liquid per foot of length of tank in United States gallons.—*Machinery.*

The area of safety valve required by the British Board of Trade is one-half square inch per square foot of grate surface when the gage is at 60 pounds. If the gage registers less than 60 pounds the area required is more, and if the gage registers more than 60 pounds the area required is less than one-half square inch per square foot of grate area.

Experiments on Fire-Boxes, Tubes and Stays*

BY ROBERT WEATHERBURN

The following experiments, instituted and made by the writer, on the fire-box and tubes of a first-class British express passenger locomotive under ordinary conditions of work, although dating back to the year 1895—and those on copper stays and staying some seven years later—may be of interest, more particularly as these parts of the locomotive have been the subject of much research and controversy during the last few years. The writer ventures to think that their value is in no ways impaired by the lapse of time, as the all-around conditions, pressure alone excepted, are more or less those of to-day. His opinions may or may not be accepted, but at least they possess the advantage of many years' close observation and practice. Heat, pressure and water, largely assisted by design and mechanical agency are responsible for the trouble experienced. Pressures within 200 pounds are right in the order of economy and efficiency. Yet the shape and strength of material used to secure a substantial and lasting effect too often defeat that end. The 7/16-inch and ½-inch thickness of fire-box plates, along with the 1-inch diameter and 4-inch pitch of stays, is sufficient. The ⅞-inch or 15/16-inch thick tube plates is also sufficient when properly designed; anything thicker will inevitably buckle and warp in time under the fiery impact of incandescent gases often centralized, and even when under the best draft conditions not properly diffused, as will be shown afterwards. The differences of temperatures between the fire and water sides of plates are productive of stresses, punishing in proportion to the thickness of plates both by wasting and distortion. These stresses are again aided by the intrusion of others which add to the burden, producing elongation in the direction of the least resistance. Irregular firing and working produce irregular temperatures. Deep fire-boxes are less subject to extremes than shallow ones, for with the latter with thick fires, which with some coals are needful, it is often the case that a portion of the tube plate is bathed in flame, which is drawn into the tubes between each beat; this periodical plugging and withdrawal causes a rise and fall of temperature on the tube plate and tubes in absolute unison with the action of the exhaust. Let us suppose a tube plate subjected to such high temperatures for the first time, the fire side would expand, thus sensibly increasing its area, but finds itself from the first in active conflict with the water side, which is at a much lower temperature, in addition to which it is opposed by the stiffness of its flanges, which at a lower temperature bind it on sides and top, but the greatest resistance that the expanding plate meets is the first vertical rows of stays to right and left; these, though intended to take a tensile stress and prevent bulging, are now under compression, unless placed at least 6½ inches to 7½ inches from the root of the flange, thus preventing the free movement of the tube plate when expanding, and eventually producing the acute hinging and distortion between them and the tube plate flange.

The combined resistance places the expanding plate under compression. Unaided these conditions are favorable to buckling or convexing on the fire side, but added to these is the expansion of copper or brass tubes acting in the same direction, and, as is unfortunately too often the case, from the base of an inflexible smoke-box tube plate and assisted by the steam pressure between the tubes.

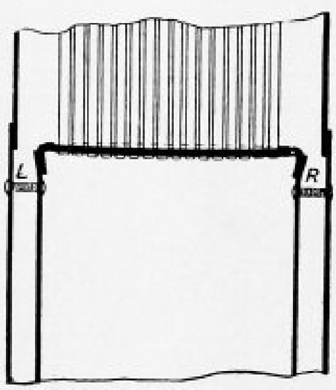


FIG. 1.—DISTORTION AND ENLARGEMENT OF TUBE PLATE

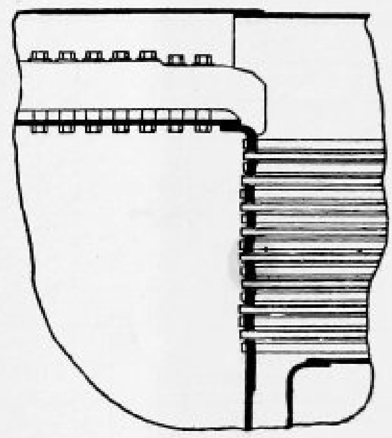


FIG. 2.—WAVY DISTORTION OF TUBE PLATE

If the crown of the fire-box is provided with sling stays, which freely allow for upward and horizontal expansion, the tube plate from that source would only meet with the resistance from steam pressure and the lengthening of the fire-box, plus the stiffness of the flanges; but if the box be mounted with girder stays their influence must be considered, binding the top plate in the most rigid manner, and if the topmost row of tubes be pierced too near the bend of the flange, then the acute hinging action caused by the expanding crown sheet and tubes acting on an inelastic part will eventually produce a fracture extending through their line. But few years' repetition of such is required to destroy the fire-box's stability and render its removal necessary. In order to explain, Fig. 1 shows the distortion across from *R* to *L*, and Figs. 2 and 3 the vertical distortion of the tube plates. The first shows the bending in of the side flanges caused by the resistance of side stays, etc., to enlargement, and the writer found that the tube plate had become ⅝ inch larger across than its original size.

The enlargement of area was solely due to mechanical agencies, *i. e.*, expanding and referruling of tubes, many of the tube holes being fully 1/16 larger than the original size—tube plate seven years old.

As the foregoing notes have been more general than specific, it will now be necessary to explain more fully the nature and action of those causes which produce deterioration.

As previously stated, the great range of temperature in locomotive fire-boxes when working on roads which vary much in inclination makes it difficult to establish the mean most usually obtained. It will be proved later on to be a

* From *The Engineer*.

question of firing as well as quality of coal. Although many isolated experiments have been made, the results hitherto have been neither conclusive nor satisfactory.

The Admiralty experiments[1] on wrought iron tube plates and tubes were of a valuable character so far as they went, and among them Mr. (now Sir John) Durston gave the mean results of eight sets of records of experiments made on the tubes of a marine boiler to ascertain the fall of temperature of the gases passing through. With a temperature of 1,644 degrees F. in the combustion chamber the gases fell to 782 degrees F. in the smoke-box, or less than one-half, after passing through 6-foot 8-inch tubes, the boiler being worked normally. With another trial under forced draft the temperature at tube plate surface was found to be about 750 degrees F., while that of the combustion chamber varied from 2,500 degrees to 2,700 degrees F. Unfortunately, the temperature of the smoke-box was not obtained; but no doubt the heat was about one-half, as other experiments with greasy water gave

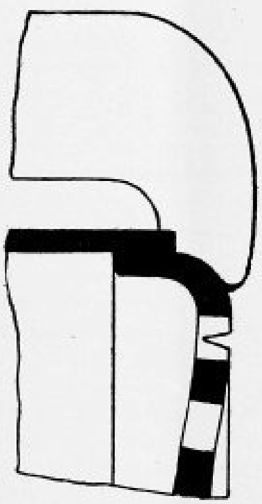


FIG. 3.—CRACK THROUGH TOP ROW OF TUBES

about that proportion. Now with a combustion chamber temperature of 2,500 degrees F., showing a falling off of 1,250 degrees F. in the smoke-box through 6-foot 8-inch length of tube, which is somewhat more than one-half the length of that of a main-line locomotive tube, which averages 11 feet, it would be only reasonable to suppose that at about that length, 11 feet, the temperature would have fallen to a little more than half the latter figures. It is asserted that experiments with the pyrometer have registered as high a temperature as 900 degrees F. in the smoke-box on a boiler fitted with 11-foot tubes 1⅝ inches diameter. This should indicate a temperature in the fire-box in excess of anything obtained by Mr. Durston; certain it is that temperatures of 2,000 degrees F. are daily occasionally reached in the fire-boxes of first-class express locomotives in this country. Cast iron fire-bars are at once melted if lifted up beyond the range of setting, and cast iron shields to protect mid-feather flanges are at times partially melted a considerable distance from the fire, which proves the temperature to be at times 2,786 degrees F.

The Admiralty experiments went to show that with a temperature of 2,500 degrees to 2,700 degrees F. in the fire-box the iron or steel tube plates at certain places attained a temperature of from 750 degrees to 1,060 degrees F., falling at places to about 300 degrees F., thus going to prove that all tubes are not alike operative.

As the foregoing experiments were confined to wrought iron or steel tube plates and tubes, their value to locomotive engineers, who in English practice principally use copper, was very limited, it therefore became needful to ascertain the action of copper plates and tubes under conditions of everyday work, for although the difference in conductivity of metals is well known, it is neither just nor safe to assume those differences in lieu of positive experience, for the forces brought into play by their expansion could not be appraised

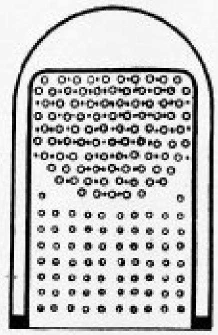


FIG. 4.—DOTS SHOWING POSITION OF TEST PLUGS

in their order by any vicarious system, owing to the extra sensitiveness of the material.

With this object and following the Admiralty plan so far as the tube plate went, the writer bored ¼-inch holes ½ inch deep between the groupings of tubes in a copper tube plate ¾ inch thick, into which plugs of tin, zinc, lead and antimony were inserted, as shown in Fig. 4; the holes being most carefully disposed over the surface of the plate which receives the greatest heat, a few being placed at the sides, the brick arch being retained undisturbed.

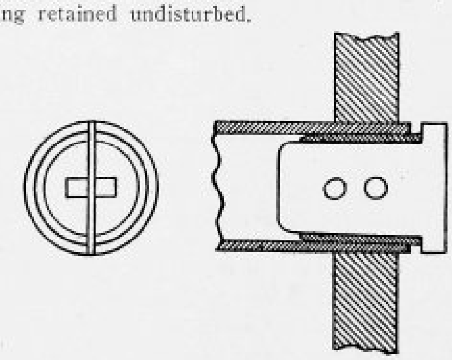


FIG. 5.—METHOD OF CARRYING TEST PLUGS IN TUBES

To obtain the temperature of the gases entering and leaving the tubes, as well as more accurately to gage the difference of temperature on the tube sheet, several strips of sheet iron and brass were inserted edgeways, 1 inch within 10 of the ferrules at the fire-box and into the corresponding end at the smoke-box, variously disposed after the same manner as the holes in the tube plate. Each plate carried a small fusible plug of either tin, lead, zinc, antimony, brass or copper, which was fixed in a hole bored a little above the center and projecting on either side of the plate, so as to catch the hottest portion of the gas stream—see Fig. 5. The trains run were in very case heavy, quick expresses—speed 54 miles per hour—and the highest temperature attained was on a rising gradient of 1 in 200, 19 miles long. The tubes were 11 feet in length. The results in tube plate were as follows:

In the fire-box tube plate the tin—442 degrees—was melted out of every hole, both at the middle and sides; the lead plugs in the holes a little above the center were melted—612 degrees—but those in the sides were intact; the zinc and antimony were, of course, unmelted. The condition of the fusible plugs fitted in the plates inserted in tubes were as follows:

Tin, lead, zinc and antimony all disappeared, the brass

[1] See paper read before the Institution of Naval Architects, March 23, 1893.

plugs—1,834 degrees—of two different kinds, namely, 5/16-inch brass wire and ordinary gunmetal, were melted in those tubes which were a little above the middle of the tube plate, but only partially melted elsewhere. At every repetition of the experiment the results were the same. The coal used was bituminous of good quality.

It will thus be seen that the highest temperature of the fire-box tube plate was 612 degrees F., and that only over about two-thirds of its area. The melting of the brass plugs and the partial melting of others fitted into ferrules proved the temperature of the entering gases to be about 1,834 degrees F., while the melting of the zinc and lead only in the tubes at the

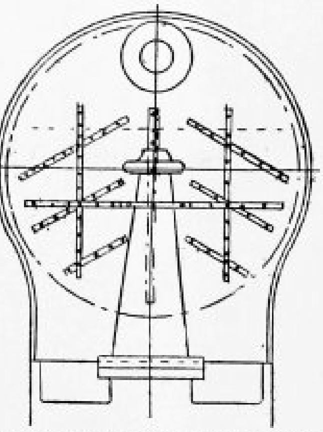


FIG. 6.—METHOD OF CARRYING TEST PLUGS IN SMOKE-BOX

smoke-box end proved the issuing gases to be between the melting point of lead, 612 degrees F., and that of zinc, 736 degrees F. Now, as before stated, the highest temperature attained was on rising gradients, and as that would only occur four times in a journey, it must be treated as occasional. At the same time the following measures were adopted to obtain the temperature of the fire side of the tubes, so as to appraise their action. Small recesses were cut 1/16 inch deep at the top and bottom of several of the copper tubes on the inside, 2½ inches from the fire-box tube plate, in which tin and lead were properly secured and made nearly flush with the surface, but after the first two trials they were found intact. It then became necessary to select metals with a lower melting point, and recourse was had to Claudel's formula, namely, an alloy of two of tin to one of lead, which melts at 385 degrees F., and with Pouillet's mixture of three of tin to one of bismuth, which melts at 392 degrees F.; these were inserted, and only in one instance was the 392 degrees F. metal melted. The 385 degrees F. metal was melted in every instance, thus showing that although the entering gases would melt brass, yet the surface of the tubes in contact with these gases took no higher temperature than 392 degrees F.

So far the firing had been skillful, a little and often, and the steaming highly satisfactory. The driver and fireman were now changed, the method of firing of the new men being larger doses and longer intervals between, meaning a somewhat deeper fire, the result being greater rises and falls of temperature. Both alloys were now melted. Pure tin was again inserted—melting at 442 degrees F.—at the bottom, and an alloy of one part tin to one part lead—melting at 466 degrees F.—at the top, the result being that both were melted on the left-side tubes, but those on the right side were still unfused.

It was no longer necessary to continue further trials, 466 degrees F. being the maximum attained, and that only on certain portions of draft area, proving again, if proof was required, that the temperatures of tube plates and tubes vary considerably according to vagaries of draft or method of firing. It may be as well to state that the blast pipe and chimney were in center and the smoke-box was tight, 4 inches to 6 inches of vacuum being registered in the same.

It will thus be seen that methods of firing are largely responsible for varying temperatures, for with the first set of men no higher temperature could be obtained than 612 degrees F. on the tube plate and 392 degrees F. on the surface of the tubes. With the second set of men and less skillful firing the tube temperature went up to 466 degrees F., or 74 degrees F. higher, so the temperature of the tube plate, rising in the same proportion, would be 747 degrees F. So far account has only been taken of the difference of the highest temperatures obtained, but the falls of temperature would be much greater, and there can be no doubt they amounted at times when running with steam shut off to hundreds of degrees. One noteworthy fact was the much higher temperature of the tube plate than the tubes in proportion to their thickness, the tubes being 10 B. W. G. and the tube plate ¾ inch thick.

The lowness of the temperature obtained in the smoke-box —something between 612 degrees F. and 736 degrees F. in comparison with former data (900 degrees F. and upwards) which were credited to the pyrometer—caused a special trial under similar conditions to the last to be made, to ascertain whether under certain conditions of gas pressure the temperature rose higher near the top or elsewhere.

For this object a clip was made and fastened round the blast pipe, from which clip thin bars of hoop iron radiated to the front and back and right and left, with cross pieces reaching up to the vicinity of the foot of the chimney, and low enough down to catch the inflowing stream of gases below. See Fig. 6. Each branch of hoop iron was bored and fitted with projecting fusible plugs in a similar manner to those fitted in the tubes, the metals employed being tin, lead, zinc and antimony. The trains worked were similar in speed and weight, and the coal used of the same quality.

The tin and lead were melted in every position; the zinc and antimony remained intact, thus giving the same results in that respect as those placed in the smoke-box end of the tubes in the former trials, proving that the temperature never rose higher than something between 612 degrees F. and 736 degrees F. in any part of the smoke-box. It therefore appeared certain that if higher temperatures were obtained at the end of the 11-foot tubes by the use of the pyrometer, if accurate, were of so transient a character as not to allow of time enough to fuse the zinc and antimony.

Personal

F. A. Scott, foreman boiler maker of the Rutland Railroad at Rutland, Vt., has resigned to accept the position of foreman boiler maker of the Ames Iron Works, Oswego, N. Y.

John Butler, formerly erecting engineer with Wm. Wood, of Media, Pa., is now installing an hydraulic plant built at Camden, N. J., for the Riverside Boiler Works at Boston, Mass.

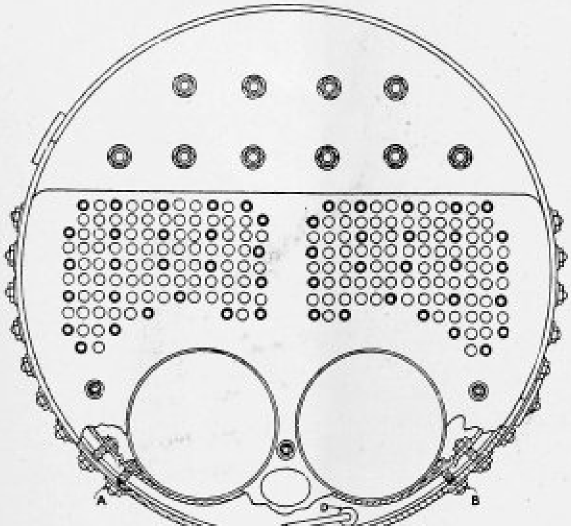
F. C. Hasse, formerly assistant foreman boiler maker of the Illinois Central Railroad at Centralia, Ill., has been promoted to the position of foreman boiler maker, with headquarters at Paducah, Ky.

H. L. Hahn, formerly assistant foreman in the boiler department, and later general boiler inspector of the Oregon Short Line, with headquarters at Salt Lake City, Utah, has returned and taken charge of the boiler department of the Santa Fe at Albuquerque, New Mexico.

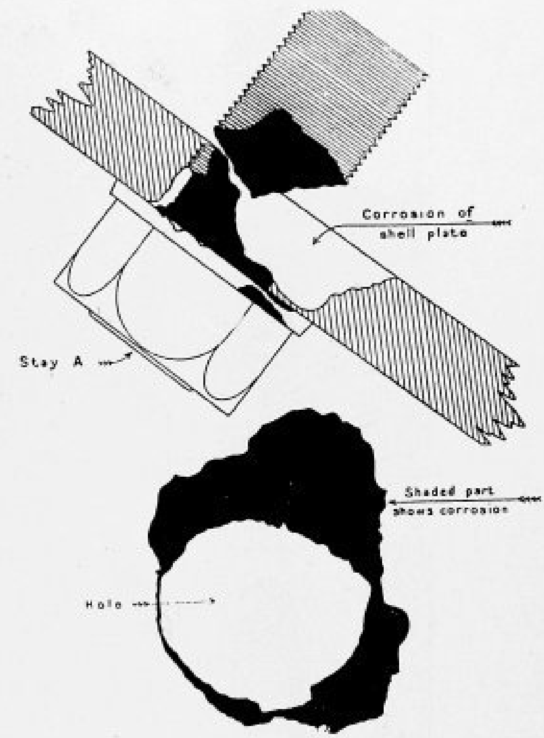
The 1913 convention of the Master Boiler Makers' Association will be held at the Sherman Hotel, Chicago, Ill., the last week in May, beginning Monday afternoon instead of Tuesday morning as formerly.

Two Curious Cases of Corrosion

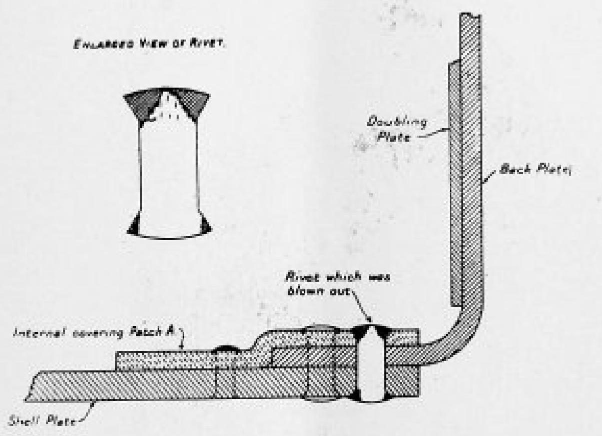
All who are familiar with the way in which steam boilers are attacked by internal corrosion know that its action is occasionally very singular. In some the plates are wasted over extended areas. In others the wasting is confined to a particular part, such as a furnace tube or end plate, or it may form a groove along the edge of an overlap or angle-iron, while in others again its attacks will be confined to rivet heads. It is seldom, however, that its peculiarities are so local or pronounced as they are shown to be in two Board of Trade reports Nos. 2066 and 2078, just issued, and which both refer to failures of marine boilers. In the first of them, which occurred to an ordinary two-furnace multi-tubular boiler on a steam trawler, the corrosion was confined to a single-screwed stud stay in the water space between one of the combustion chambers and the circular shell, and the wasting, though local, was extremely severe, as will be seen from the view which we reproduce from the report. The strange part about the occurrence was that there was no sign of wasting in any other part of the boiler, which was only about three years old, and which had been carefully inspected, both by the superintending engineers of the owners and the inspectors of Lloyd's Register, and tested by hydraulic pressure to 360 pounds on the inch (double the working pressure) on at least two occasions. No inkling that anything was wrong was afforded until the day of the accident, when the bolt head outside the shell was suddenly blown off, and the contents, escaping at a pressure of about 175 pounds, scalded the second engineer to death. In marine boilers corrosion from galvanic action is more liable to occur than in land boilers, and its effects are in some ways markedly local, but in the failure under notice no such explanation could be put forward with any degree of plausibility. There was no copper or brass object in the neighborhood, and to further guard against galvanic action, the boiler was protected with zinc slabs. The suggestion that some corrosive acid might have caused the trouble was equally untenable, for its effects, even if severe, would not have been



REPORT NO. 2066.—VIEW OF BOILER SHOWING POSITION OF CORRODED STUD STAYS



REPORT NO. 2066—ENLARGED VIEWS SHOWING CORROSION OF STAY AND SHELL PLATE



REPORT NO. 2078.—VIEW SHOWING WASTAGE AND POSITION OF RIVET WHICH WAS BLOWN OUT

confined just to one spot covered with a radius of 3 inches from the center of the stay, while "no other part of the interior of the boiler showed any similar corrosion." The case, in fact, was a complete puzzle to the commissioners who conducted the inquiry. They stated "they could find no answer which satisfied them, and certainly no answer which they could hope would satisfy anyone else."

This conclusion is unique. Over 2,000 reports have been issued by the Board of Trade on boiler failures, and this is the first occasion to our knowledge where the element of mystery has been so pronounced.

The second report (No. 2078) deals with a failure comparatively trivial in itself, viz.: the blowing out of a rivet, though as the case just considered shows, at high pressures and in confined stokeholds on board ship, sudden escapes of steam may be fatal, while the safety of a ship may even be involved in heavy weather if the boiler is disabled, and hence such failures cannot be treated lightly. We refer to it, however, mainly as a further sample of freak corrosion. The rivet was in a patch at the bottom of the shell, at the back-end seam, as indicated in accompanying sketch. The countersunk heads were eaten away, so that only the shank was left, and this was blown out by the working pressure of 170 pounds on the inch. There had been previous corrosion in this part of the shell, and the patch was originally applied in consequence.

This corrosion was thought to be due to galvanic action arising from the presence of a copper pipe near this part of the boiler, and to protect the patch it was covered with cement, but this precaution failed to prove efficacious, as, we may observe, it has failed in other instances we can recall, owing to the cracks in the cement allowing water to get in contact with the surface. The corrosion was not confined exclusively to the rivet head, though it was there most pronounced, probably owing to the upsetting of the molecular structure in the process of riveting, but was spread more or less over the adjacent neighborhood, in this respect differing altogether from the screwed stud stay already described. Although no one was injured by the escape of the boiler contents the ship was disabled, and had to make signals of distress to secure assistance back to port.—*Vulcan.*

Boiler Explosions in Mexico

A valued contributor has sent us the three photographs shown herewith in which are illustrated the effects of two recent explosions of locomotive boilers in Mexico. Figs. 1 and 2 show a boiler which was exploded by excessive pressure, due to the fact that the steam gage did not register correctly, so the machinist was looking for the trouble in the wrong place—he was screwing down the safety valves instead of testing the gage. Fig. 3 shows the effect of low water, on account of which the boiler exploded, killing three men. The boiler itself was blown 150 feet from the running gear. The boiler was constructed with a radial stay firebox, and as frequently happens with this style of boiler, the crown sheet gave way when low water occurred.

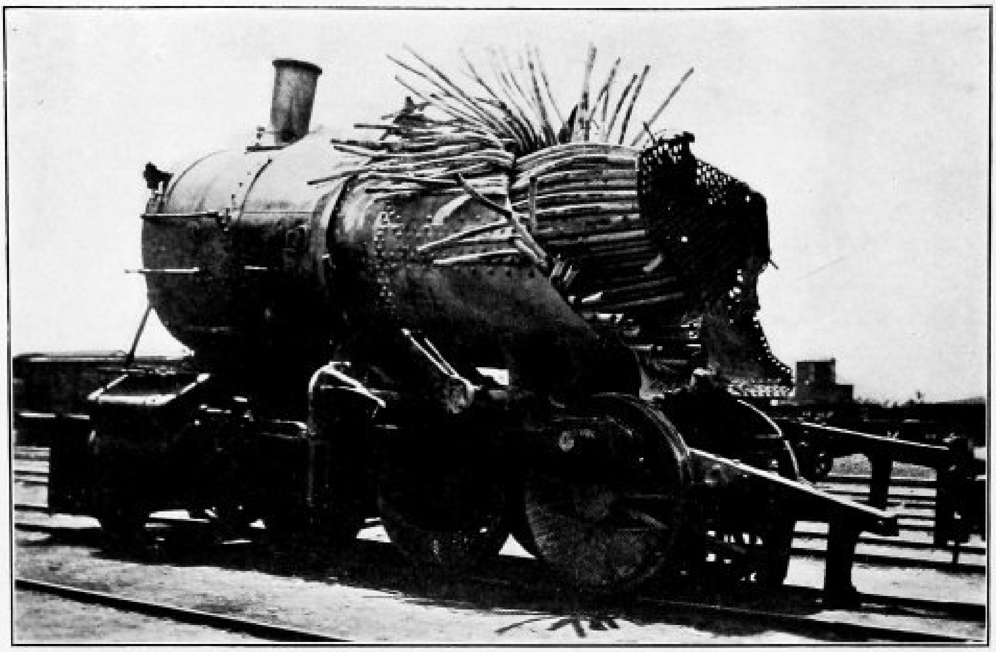


FIG. 1.—AN EXPLOSION CAUSED BY A FAULTY GAGE

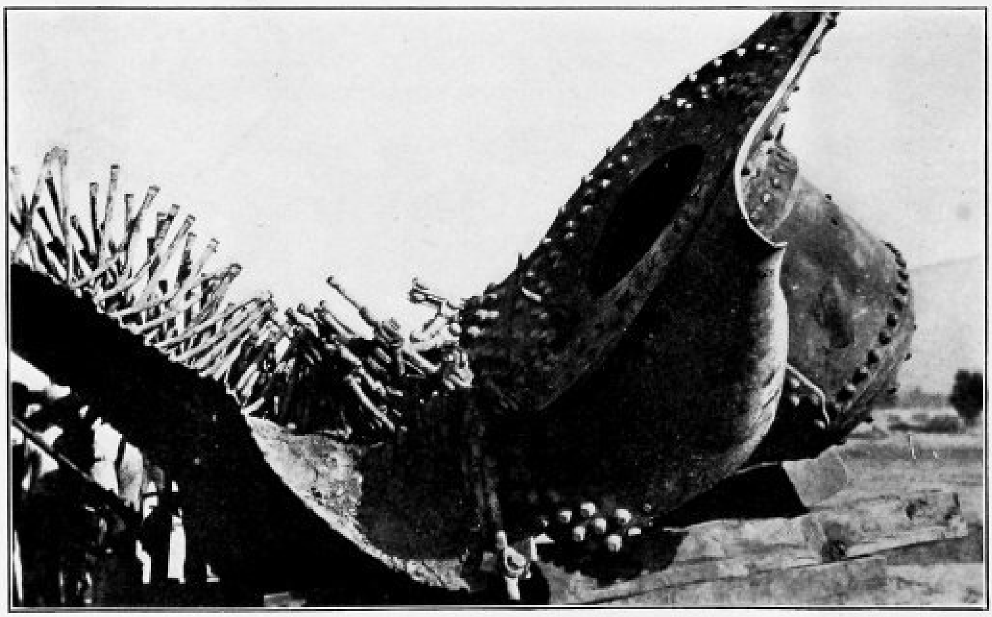


FIG. 2.—DOME, PART OF SHELL AND PART OF OUTSIDE CASING BLOWN 600 FEET FROM THE ENGINE

Present Tendencies in Locomotive Design

A study of present-day tendencies in locomotive design points unmistakably to the fact that those tendencies are inspired, more than ever before, by the desire to achieve economy in operation and in maintenance. Essential to this end are high powered units and simplicity of construction. The former is now being realized in a manner that makes locomotive practice of ten years ago seem but elementary; while the latter always has been a distinctively American characteristic, which is being retained to a surprising extent, considering the evident drift of affairs only a few years ago. Probably no one phase of the locomotive question is more significant of the desire to achieve economy in construction as well as in operation and maintenance than is the remarkable advance made during the past two years or so in the development of the rigid wheel base locomotive, particularly those of the Mikado type. Nor is this advance stopping with capable of exerting a tractive effort of 60,000 pounds, which is sufficient to handle trains containing up to 100 loaded cars, representing something very near the limits of practicability with cars as at present constructed. Only a few years ago it might have been expected that the Mallet compound would assume a prominent place as a road engine for heavy freight service, but it has been discovered that that type of engine is limited in its adaptability, and should, in order to derive the most satisfactory results, be designed with particular regard for the service in which it is expected to operate. In specialized service, such as pushing or otherwise helping over steep mountain grades, the Mallet engine is of well-proven value, and may hardly be expected to decline in popularity for purposes requiring unusually large capacity concentrated in a single unit.

The inclination, if one ever existed, to adapt the Mallet

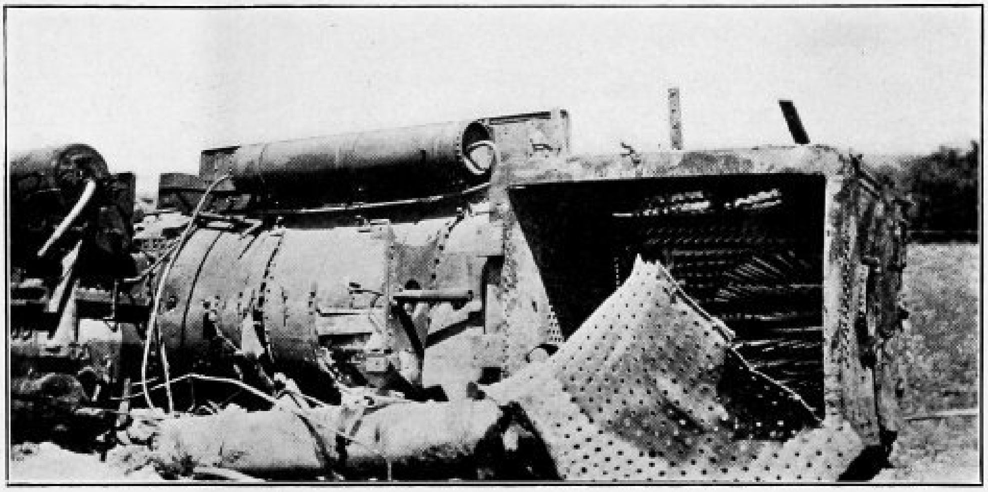


FIG. 3.—THE RESULT OF LOW WATER IN A RADIAL STAY BOILER

the development of the Mikado engine, since we just recently have had afforded us the example of the 2-10-2, or Santa Fe type engine, built by the Baldwin Locomotive Works for the Chicago, Burlington & Quincy Railroad, in which with a single pair of simple cylinders is made available a tractive effort of 71,500 pounds. This is the equivalent of the power developed by the original Mallet compounds of the Baltimore & Ohio, which less than ten years ago were thought to be nothing less than phenomenal as regards size and capacity.

As a limiting factor in the size to which our locomotives may be developed, we have long recognized, and probably always will have to contend with, the present standard gage of track. This is common to all roads alike. Another factor rapidly growing less common is the restriction imposed through the lack of capacity of track and track structures to carry concentrated loads in excess of 60,000 or 70,000 pounds per axle; while yet another feature that serves to limit the size of rigid wheel-base engines, at least on many roads, is the presence of excess curvature in the track. The limitations imposed by width of gage would seem to have been compromised to almost as great an extent as is permissible, while track and track structures are being strengthened and curvature is being eliminated sufficiently to permit the running of engines having axle loads of 60,000 pounds or over and a rigid wheel base sufficient to accommodate five pairs of drivers. Thus an engine having four pairs of complex drivers, imposing on the track a load of 240,000 pounds, is engine to road conditions, was away from rather than in harmony with the principle of simplicity in construction that has been retained in the high-power, rigid-wheel-base engines, and a review of the means by which the higher power has been attained in the latter types reveals at the same time a number of the factors through which much of the economy in locomotive operation has been made possible. Taking, for example, the American Locomotive Company's locomotive No. 50000, which undoubtedly represents the culmination of the best practices at the present time characteristic of American locomotive design, we find superfluous weight has been eliminated. Steam passages have been made as simple and direct as possible, and fuel-saving apparatus in the form of superheating and brick-arch equipment has been provided. The reduction in weight in proportion to the power developed was made possible both by very careful attention to details and by taking advantage of the superior strength of vanadium-alloy parts, such as cylinder castings, axles, rods, frames, etc. The number of engines containing parts in which this alloy is used is constantly increasing, so much so that there are now something like 1,000 engines in service with vanadium-steel frames, on which there have been less than 1 percent of breakages, and other parts, such as axles and rods, are meeting with equal success. This condition resolves itself into an important factor in the economy of operation and up-keep. The success of the design in locomotive No. 50000, from the standpoint of fuel economy and the measure of advancement in this respect during the past ten years, may be judged from the fact that this engine, running at 51 miles per hour, on a road test consumed an average of but 2.21 pounds of coal per indicated horsepower-hour, while the best performance at the same speed of the several passenger locomotives tested at the Louisiana Purchase Exposition was 3.17 pounds of coal per indicated horsepower-hour. That, by the way, was accomplished not on an American but on a foreign-built engine, so the advancement made in this country is even greater than is indicated by the figures quoted.

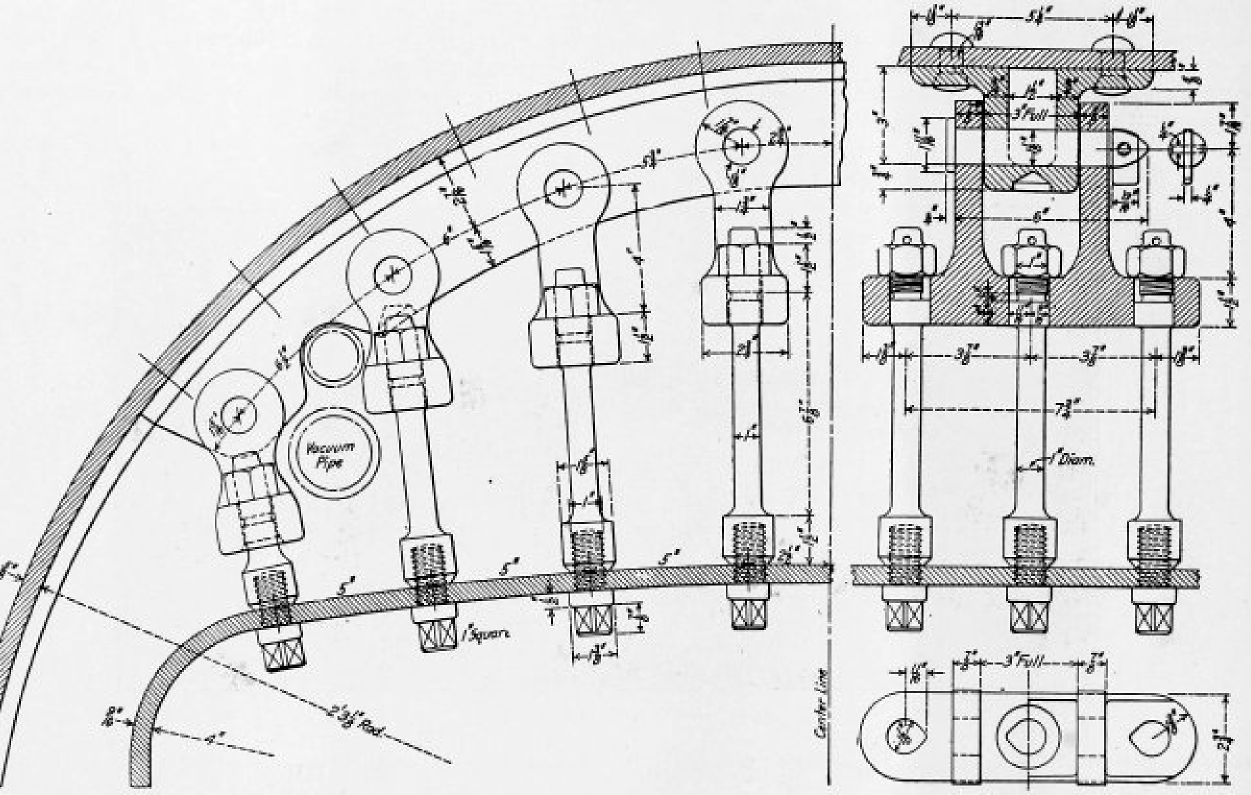
It is to the credit of the superheater and the brick arch that much of this economy has been made possible. The aggregate of the total savings is made more apparent by the fact that there are now in use some 11,000 engines fitted with brick arches, fully 70 percent of those ordered during the first five months of this year having been so equipped, and from the fact that some 90 percent of the engines to be ordered during the current year are expected to be fitted with superheaters, there now being a total of about 4,500 engines having this apparatus.

Since the limit of a fireman's capacity is approximately 5,000 or 6,000 pounds of coal per hour, it follows that the automatic stoker must be depended on to come to the relief in cases where as much as 8,000 pounds of coal per hour must be fired. The success that two or three designs of this apparatus have had while going through their experimental stages is practical assurance that the limit in coal-burning capacity is dependent on mechanical means rather than on human endurance—to all practical purposes becoming a case in which a limit is no longer imposed. These and other improvements have been brought out and are being so generally adopted that standard American locomotive practice seems to be rapidly crystalizing into the production of the greatest possible amount of power in proportion to the weight of the individual machine, at the same time using the least possible amount of fuel. Taken on the whole, current practice can safely be taken as being from 30 to 40 percent more efficient on the basis of fuel consumed than was the approved practice as recently as five years ago.—*The Railway and Engineering Review.*

A Novel Design of Sling Stay

BY GEORGE SHERWOOD HODGINS

The boiler sling stays on the London & South Western express and tank engines are simple in construction and strong. On the roof sheet of the boiler, over the flue sheet, an old form of U-rail is riveted, and to this, at regular intervals, are pinned the crows' feet. The pin used is sharpened at one end and has a hinged key at the pointed end. This enables it to be pushed into place easily, and when in position the hinged key automatically locks it.

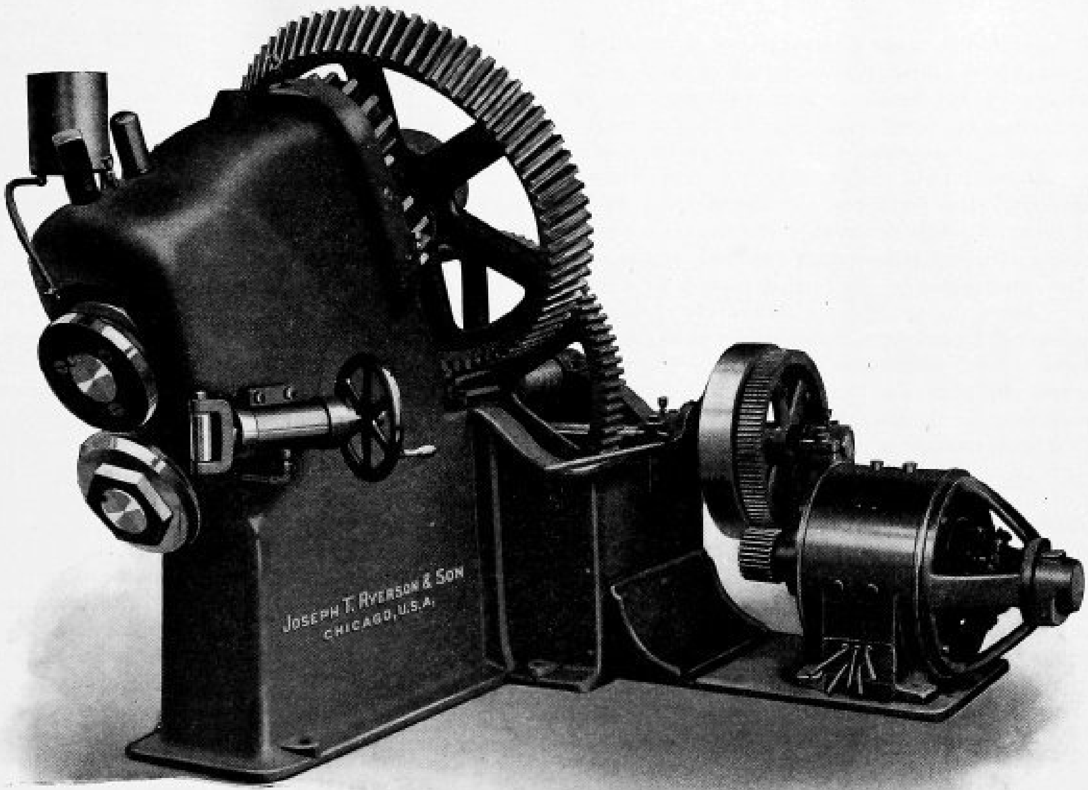


TYPE OF BOILER SLING STAY USED ON LONDON & SOUTHWESTERN LOCOMOTIVES

The stay itself drops through a hole in the crow's foot, and is secured in place by a nut with a split key above. The "neck" of the stay has a pin on one side which fits into a recess in the crow's foot, and this enables the nut to be put on above, and the tap bolt entered from below. This arrangement subsequently prevents the stay from turning or slackening in any way. The crown sheet stay is practically a tap bolt, which screws through the crown sheet and up into the enlarged socket at the lower end of the stay.

The whole arrangement is such that the stay is always tight in the crown sheet, and any vertical movement of the flue sheet tends to lift the nut on the crow's foot and provide the necessary "give and take" for the expansion and contraction of the fire-box.—*American Engineer.*

Smoke abatement is the subject selected for discussion at the October meeting of the American Society of Mechanical Engineers in New York. In this connection it is desired particularly to bring out all available data to support the contention that smoke abatement is an economical advantage to the coal consumer as well as a direct benefit to the community.



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Relation of Mechanical Appliances to Fuel Economy*

The only object in burning fuel is to obtain from it the stored-up energy and utilize this energy to produce motion. This being the case, any device or mechanical appliance that will enable us to obtain more energy from a given amount of fuel, or to utilize, by converting into work, a greater part of the energy contained, must be classed as a distinct factor in the fuel problem. The percentage of economy, due to any mechanical device, can be calculated by the increased amount of work obtained from a given quantity of fuel; and as work in this instance means motion, the time element must enter in the problem. Therefore, to get the true measure of economy for any mechanical device, the work must be measured, not in train or engine miles, but in ton miles per hour. The relation of any mechanical appliance to fuel economy would, therefore, be in proportion to the decrease in fuel consumption per mile in hauling the same tonnage at the same speed; to the increase in speed with the same tonnage on an equal amount of fuel per mile; or to the increased tonnage hauled at the same speed on the same consumption of fuel per mile run.

Viewing the proposition from this standpoint, there is no question but that of all mechanical appliances the high degree superheater stands pre-eminently at the head. The most comprehensive and carefully conducted tests carried out in this country, with a view to obtaining definite data bearing on the fuel economy due to the use of superheat, were made by the New York Central, in connection with the Pennsylvania Railroad in 1910. The final results of these tests are shown in the following table, in which it is seen that the saving in fuel due to superheat (allowing 2.3 percent as due to improved circulation of the arch tubes) was equal to 26 percent, while the total saving due to the installation of a brick arch and a superheater was equal to 33.3 percent. This test also shows that the application of the brick arch resulted in a net saving in fuel of 7.3 percent.

A series of tests, conducted by the chairman, covering a period of several months, showed that the increase in fuel economy is proportionate to the increase in tonnage, which proves the theory that the efficiency of a superheater locomotive is proportionate to the increase in superheat, and the degree of superheat depends on the rate of combustion; the rate of combustion being necessarily higher when handling an increased tonnage at the same rate of speed. The final results checked very closely with the results found on the New York Central and the Pennsylvania.

DRY COAL PER DYNAMOMETER H.P. HOUR

Speeds.	Saturated Steam, No Arch.	Superheater.	Superheater and Brick Arch.
12.5	4.67	3.15	2.90
15.0	4.75	3.56	3.25
17.7	4.69	3.40	3.27
Average	4.70	3.37	3.14
Relative coal consumption.	100	71.7	66.7

Undoubtedly, next in order, as a mechanical appliance affecting fuel economy, is the brick arch, although the feed-water heater runs it a close race and in some instances precedes it. The value of the brick arch as a fuel economizer is due (where arch tubes are used to support it) to the increased heating surface of these tubes, and to the better utilization of the fire-box heating surface.

No better illustration of the method by which the application of the brick arch utilizes the full fire-box area to the best advantage can be given than that shown in the article contributed to the February, 1912, number of the *American Engineer*, by F. F. Gaines, superintendent of motive power of the Central of Georgia, from which the table at the bottom of page showing the results of several tests is taken.

It will be noticed that by a change in fire-box construction and the substitution of a vertical hollow wall an even greater fuel economy is effected, and there is no question but that if this type of fire-box was used in connection with a high degree superheater, a greater percent of the energy now unavoidably lost in the present type of locomotive would be conserved.

The economical value of the brick arch depends on the type of boiler, the relation between the fire-box heating surface and the tube heating surface, the nature of the fuel and character of the service, and it is due to the failure to take into consideration the above essentials that so many widely varying results are obtained, and so many different opinions find credence for and against the value of the arch. Facts are stubborn things, however, and as repeatedly verified tests can be taken as facts, we can safely assert that in the majority of the present-day locomotives the intelligent application of a correct brick arch will result in an economy of fuel ranging from 5 to 15 percent.

(*Continued on Page 317*)

* Committee report read before the Traveling Engineers' Association, Chicago, August, 1912.

Engine Number.	Train Number.	Date.	Actual Time Consumed.	Stops. Number.	Stops. Time Consumed.	Pounds Coal Consumed. Total.	Pounds Coal Consumed. Per 1,000 Ton Miles.	Pounds Coal Consumed. Per Hour.	Pounds Water Evaporated. Total.	Pounds Water Evaporated. Per Pound of Coal.	Miles Run to One Ton of Coal.	Tons Coal Used in Excess, Based on Engine 1014 as Unit of Comparison.	Relative Efficiency Based on Coal Consumption per Mile.
*1014	Extra	1/13/11	6 hr. 34 m.	6	1 hr. 4 m.	11,950	93	1,820	96,800	8.10	16.74	......	......
.....	2/36	1/14/11	6 hr. 42 m.	8	1 hr. 33 m.	13,350	104	1,991	109,000	8.16	14.98	......	......
1014	3/37	1/16/11	6 hr. 12 m.	7	49 m.	12,450	97	2,008	105,750	8.49	16.08	......	......
.....	1/36	1/17/11	6 hr. 39 m.	7	1 hr. 12 m.	14,250	111	2,143	109,800	7.71	14.04	......	......
.....	.....	....	26 hr. 7 m.	...	4 hr. 38 m.	52,000	101	1,991	421,350	8.10	15.38	......	100.00
†1012	Extra	1/18/11	7 hr. 12 m.	5	57 m.	20,400	159	2,833	121,458	5.95	9.80	......	......
.....	1/36	1/19/11	8 hr. 4 m.	5	1 hr. 16 m.	21,900	170	2,715	124,887	5.70	9.13	......	......
1012	Extra	1/20/11	6 hr. 43 m.	5	45 m.	19,087	148	2,841	113,095	5.93	10.48	......	......
.....	2/36	1/21/11	7 hr. 20 m.	8	1 hr. 43 m.	22,500	175	3,068	121,883	5.42	8.89	......	......
.....	.....	....	29 hr. 17 m.	...	4 hr. 41 m.	83,887	163	2,865	481,323	5.74	9.54	15.94	61.96
‡1716	Extra	1/23/11	8 hr.	9	2 hr. 33 m.	15,000	117	1,875	110,400	7.36	13.33	......	......
.....	1/36	1/24/11	7 hr. 24 m.	10	1 hr. 41 m.	16,500	128	2,230	120,000	7.27	11.43	......	......
1716	Extra	1/25/11	6 hr. 50 m.	9	1 hr. 20 m.	13,800	107	2,080	102,801	7.45	14.49	......	......
.....	1/36	1/26/11	7 hr. 28 m.	12	1 hr. 42 m.	15,600	121	2,089	117,166	7.51	12.82	......	......
.....	.....	....	29 hr. 42 m.	...	7 hr. 16 m.	60,900	118	2,050	450,367	7.39	13.14	4.45	85.58

* Engine 1014—21 in. x 32 in. Cooke consolidation—with new firebox and combustion chamber, with hollow brick wall and provision for mixing hot air with burning gases. Total heating surface, 2,987.33 sq. ft.

† Engine 1012—Same class engine as 1014, but with original boiler unchanged, and brick arch. Total heating surface, 3,022.29 sq. ft.

‡ Engine 1716—22 in. x 30 in. Baldwin consolidation—brick arch. Total heating surface, 3,230 sq. ft.

Analysis of fuel: Moisture, 1.39 percent; volatile combustion matter, 30.56 percent; fixed carbon, 55.11 percent; ash, 12.94 percent; sulphur 1.5 percent. B.t.u. per pound dry coal (Mahler Atwater calorimeter), 13,179; B.t.u. per pound actual coal, 12,996.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

If the boiler-making trade is to be a progressive one, or even if it is to maintain its present state of excellency, the younger men or boys who come into the boiler shops should be given a chance to learn the trade in a thorough manner, so that when the proper time comes they can take up the responsibilities now carried by the older men and, if possible, improve upon their work. In a few shops which are connected with large corporations, such as railroads and shipyards, the training of boiler-maker apprentices is well taken care of by a system of apprentice schools, but when it comes to the independent-contract boiler shops, which have no connection with a large industrial system with its department of apprentice schools, the boys are thrown more or less upon their own resources to learn the trade. This does not mean that the opportunities in the contract shops are not so good as in the railroad shops, for frequently the beginner in a contract shop will find a greater variety of work, and, if he goes at it in the right spirit and the boss is of the right sort, he will not be neglected, but will receive every encouragement to better himself in the trade, but what is needed in the contract shop is closer personal supervision over the apprentices and a more logical effort to instruct them in the technicalities of their trade.

One of the most useful things that a boiler maker can do to help himself over the rough places, and, incidentally, to help out his fellow workmen, is to take note of the various tools, special appliances and methods used in the shop in which he is employed, and compare them with the tools, devices and methods that he hears of, reads about or sees in other shops, so that he can understand fully wherein their advantages lie and turn them to account in his own work. If an unusual device or tool, or a unique method of doing a special job is used in a particular shop, it has probably been adopted because it involves some improvement over the ordinary method of doing the work, and represents either a saving in time and expense or the production of a better grade of work The tool or method, or, more especially, the idea behind it, is something of value, and the possession of it will in the end prove a valuable asset. For this reason, then, if for no other, it will pay in the long run for a man to develop his powers of observation to the fullest extent, so that he will accumulate from his daily experience a fund of useful information that eventually will entitle him to the position of a master boiler maker. Ordinary work well done is the first requirement in any shop; but in an up-to-date, progressive shop new ideas and the ability to adapt means to an end are quickly noticed.

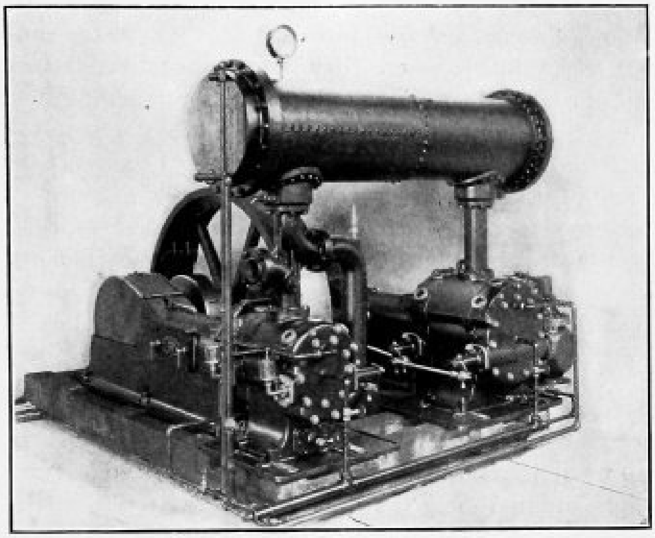
At a recent meeting of the New York Railway Club a paper was read discussing the comparative performances of locomotive boilers equipped with radial stay and sectional fireboxes. The paper itself was based upon the tests recently conducted at Coatesville, Pa., by Dr. Goss, reference to which has already been made in previous issues of this journal and which will be taken up in more detail at a later date when Dr. Goss' complete report of the tests is issued. Briefly summarized, the important points brought out in this paper were that practically the same evaporative efficiency was obtained with both types of boilers, with possibly a slight advantage in favor of the sectional firebox when operated at high rates of combustion with coal as fuel; that one square foot of firebox heating surface is equivalent to 7.6 square feet of flue surface for evaporating purposes, and that the sectional firebox is practically immune from the danger of explosion on account of low water, and, therefore, is a safer type of construction than the radial stay boiler, which is liable to fail under low water conditions. Although the sectional firebox has been in service only a short time, yet it was brought out in the discussion of the paper that, in so far as available records of brief service show, the sectional firebox has been less troublesome to maintain than the radial stay boiler, as there is less tendency for scale to accumulate and the facilities are better for cleaning the box. There also seems to be evidence of a less tendency for the development of cracks in the sectional firebox, and, consequently, the sectional firebox would be expected to outlast the radial stay firebox. These points, however, will remain debatable until further proof is available from a more extended trial of the new firebox.

New Improved Engineering Specialties for Boiler-Making

A New Air Compressor

The Chicago Pneumatic Tool Company, Chicago, has placed on the market a new enclosed, self-oiling, belt-driven air compressor, known as Class M-CB, which has two-stage air cylinders, 16 inches and 10 inches in diameter and 12 inches stroke. At its rated speed of 210 revolutions per minute it has a displacement of 576 cubic feet per minute.

Mechanical inlet air valves of the semi-rotary Corliss type are used, actuated by eccentrics on the compressor shaft. The



discharge valves are of the company's air-cushioned poppet type, placed radially in the heads. This combination, it is claimed, insures high volumetric efficiency and the elimination of valve troubles, as the valves are interchangeable and accessible for adjustment and renewal.

The heads and cylinder walls are completely water-jacketed and arranged with independent water supply, permitting the use of solid gaskets between heads and cylinders. The frames are full tangye type with bored crosshead guides completely enclosing the crosshead bearings. The cranks and eccentrics are enclosed with substantial planished iron casing, enabling complete flood lubrication of the main bearings, crosshead and moving parts by means of automatic gravity lubrication. Inlet valves and pistons are lubricated by large glass sight-feed lubricators on the caps of inlet valves, and all valve gear bearings have extra large compression grease cups.

The inter-cooler is of the steel shell marine condenser type, mounted overhead, provided with composition tubes, baffle plates and separator drip pockets. The air cylinders are bolted directly to the tangye frames, and in addition extend down to large sole plates with drip guards all around.

The cranks are of the balanced disk type pressed and keyed to shaft. The driving pulley is split-keyed to shaft and machine-true on face and edges. It is of unusually heavy design to give the necessary fly-wheel effect.

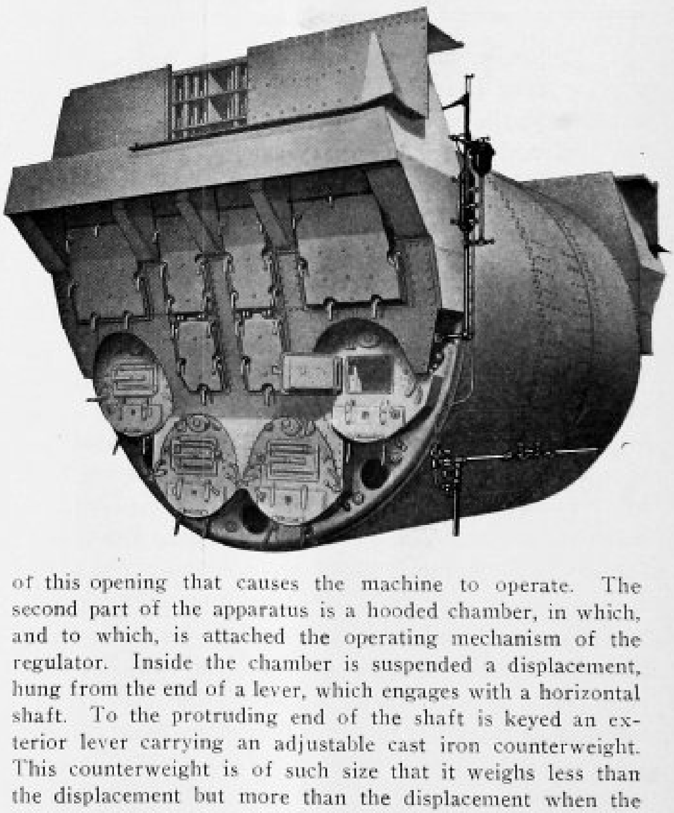
Control is effected by an improved throttling in-take controller operated by receiver pressure, capable of close regulation and adjusting the load to meet the air demands, so that the power consumption is reduced to a minimum.

The same type of machine is furnished in capacities up to 4,000 cubic feet per minute. Equivalent sizes and capacities can be furnished in short belt drive and motor drive with motor mounted directly on compressor shaft.

The Vigilant Marine Feed-Water Regulator

The Vigilant Feed Water Regulator, manufactured by the Chaplin-Fulton Manufacturing Company, Pittsburg, Pa., is an apparatus designed to regulate the water level in boilers of every description. By its action it is claimed that the water level is held constantly at one point with less than ¼ inch variation, introducing the feed-water in exactly the same quantity as the steam is evaporated. It is of simple construction, so that it cannot easily get out of order, and any one who is competent to operate a boiler can easily understand its operation. The manufacturers claim that it will furnish dry steam to the engines on account of the regulation of the feed pumps, in accordance with the load on the boilers. Also, that it increases the efficiency of the heaters and economizers, maintaining a uniform temperature in the boilers, thus preventing excessive strains from contraction and expansion, and resultant leakage or the burning of fusible plugs. There are no floats or concealed parts to obscure steam passages in the apparatus, but the whole device stands in plain view and can be examined at any time without disturbing the boiler. Should any accident occur to the regulator the change to hand regulation can be accomplished in less than a minute.

The apparatus consists of three essential parts. The first is a special combination union angle valve, which must be inserted in the boiler at the point where it is desired to maintain the water level. The opening in the end of the threaded nipple, having a ½-inch pipe, is half-round, with the top horizontal, and it is the alternate submersion and uncovering



of this opening that causes the machine to operate. The second part of the apparatus is a hooded chamber, in which, and to which, is attached the operating mechanism of the regulator. Inside the chamber is suspended a displacement, hung from the end of a lever, which engages with a horizontal shaft. To the protruding end of the shaft is keyed an exterior lever carrying an adjustable cast iron counterweight. This counterweight is of such size that it weighs less than the displacement but more than the displacement when the latter is submerged. The controlling valve is the third part of the regulator, and is placed in the feed line of the boiler, usually in a by-pass, so that it can be cut out at will. In construction it is similar to a check valve.

When the water level in the column is below the opening of the special nipple, the difference in pressure on the valves of the apparatus, as controlled by the weights and steam pressure, will open the controlling valve and admit water to the boiler. When the boiler fills up to the opening of the special nipple, the stem will be sealed by the rising water, the controlling valve closed and the feed-water shut off. No more water can enter the boiler until the water falls to the opening of the special nipple. When steam is admitted to the top of the chamber the water in it falls to the old level, all the operations are reversed, and the controlling valve opens again. The operations are repeated as the water gets above or below the desired point.

"Quickwork" Rotary Shears

The "Quickwork" rotary shear was developed and is manufactured by the inventor, H. Collier Smith, 125 Harper avenue, Detroit, Mich., to meet the demand existing in almost every sheet metal working establishment for cutting irregular shaped parts without involving the expense of blanking dies. In the average plant that has to do with the cutting of sheet metal, from the lightest to the heaviest gages, there is constant necessity for cutting irregular parts, not sufficient in quantity to justify the expense of blanking dies, but requiring laborious and expensive labor, with the usual equipment; in fact, the average plant is not equipped with presses necessary for the

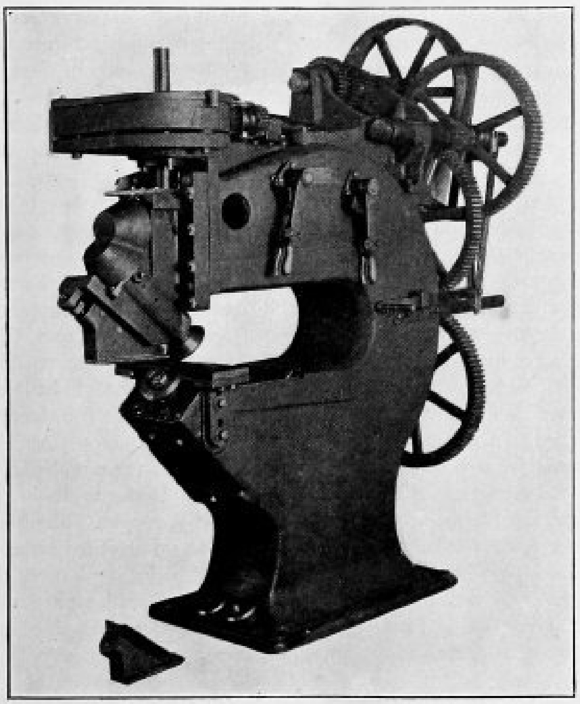


FIG. 1.—TYPE 4, 3/8-INCH CAPACITY, "QUICKWORK" ROTARY SHEAR (PATENT APPLIED FOR)

use of blanking dies. The usual method of making irregular cuts entails a great loss in material and labor by reason of the necessity for allowing a considerable amount of extra stock in the preliminary roughing out of the parts, and then the final cut must be made by piece-meal cutting and punching or notching approximately along the line, and finally finishing up the edge of the metal by chiseling or filing away the jagged and irregular corners resulting from notching or piece-meal cutting.

With the "Quickwork" rotary shear the parts are scribed from patterns on the sheet as close together as the shape of the pattern will allow, and then, instead of roughing out the parts preliminary to cutting, the first, last and final cut is made with the "Quickwork" rotary shear in one passage through the machine with ease and accuracy. This applies to openings in the middle portions of sheet without cutting in from side, as well as to cuts which start from the side of the sheet.

An elbow is a typical example of irregular cutting. Figs. 3 and 4 show a comparison of the usual method and the "Quickwork" method of cutting out elbows. Fig. 3 represents a sheet of metal with the four parts, *A*, *B*, *C* and *D*, respectively, scribed out on the sheet all ready for cutting by the usual method. It is necessary to scribe these parts some distance apart in order to be able to rough them out by cutting with a straight shear along the heavy dotted lines, after which this surplus metal is cut away piece-meal, as indicated by the

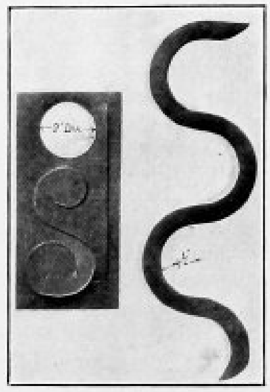


FIG. 2.—SAMPLE OF CUT BY "QUICKWORK" ROTARY SHEARS

light dotted lines, the curved portions of the lines being notched out with a slotting punch, as indicated. Fig. 4 represents the sheet of metal with the four parts scribed out on it ready for cutting with the "Quickwork" rotary shear, and it will be noted that the parts are nested closely together without any space between, it only being necessary to cut along the line with the shear, which not only separates or roughs out the parts, but completes them at one passage across the sheet, and leaves a true, square edge and flat true parts. It can readily be seen that the four parts of the elbow can be cut out with the "Quickwork" shear in a small fraction of the time

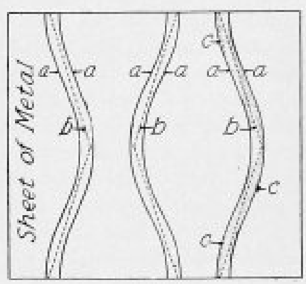


FIG. 3

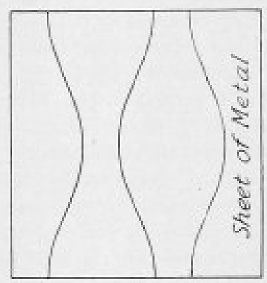


FIG. 4

required for cutting it out by the usual method. The comparison here shown holds good with any kind of irregular work.

In this machine the metal is self-feeding through the cutters, and comparatively little effort is necessary for its guidance in cutting to the line. The cutting of reverse curves is made easy by reason of the fact that both cutters are inclined with relation to the plane of the metal being cut; thus both cutters present similar and symmetrical rounded or conical-shaped adjacent faces to the cut edges of the metal, so that the sheet can be guided to the right or left, and a cut be made in either direction with equal facility.

The upper cutter with its shaft and beveled driving gears are mounted in a gib casting which is raised and lowered by a screw, driven by power through the medium of a worm and gear. The raising and lowering of this cutter is controlled by the forward pendant lever, so that in cutting an opening in heavy metal it is only necessary to move the lever for raising the cutter, allowing the insertion of the metal, and then move the lever the other way for lowering the cutter through the metal. The horizontal handle to the right controls the main drive clutch by means of which the machine is started and stopped instantly as desired.

These machines are provided with variable speed drive of the gear type, affording three speeds, controlled instantly, as desired, by the rear pendant lever. The variable-speed mechanism consists of three pairs of gears, that are always in mesh, and a sliding key in the lower shaft, that is shifted from one pair of gears to another by moving the lever. There is an automatic stop mechanism for controlling the vertical travel of the gib casting carrying the upper cutter. This stop mechanism can be quickly adjusted to control the worm gear drive clutch, so that the exact point to which the cutter must be lowered with relation to the lower cutter in order to produce the best cutting results is automatically governed. A safety knock-out is also provided to prevent raising the gib casting high enough to jam in its topmost position. A vertically adjustable supporting-stripping table of hardened steel is provided across the machine behind and partly around the lower cutter, and a vertically adjustable tool-steel-faced stripper is provided in front of and partly around the upper cutter. Thus the metal is guided in a horizontal position and the tendency of the cut metal to follow around the rear edge of the cutters is counterbalanced, making the guiding of the metal as easy as can be expected, considering the gage.

Pressed Steel Tanks

A pressed steel tank built up of units has recently been placed on the market for use where lightness, cheapness, compactness in handling and in storing when knocked down and rapidity of erection are desirable. The plates are in standard units, 4 feet square, 1/4 or 5/16 inches thick, depending on the depth of the tanks. Flanges are 3 inches wide and are provided with holes for 5/8-inch bolts. Joints are made with strip lead 2½ by 1/8 inches, calked from the inside after bolting. No rivets are used, so the tank can be set up without skilled labor. Stays of 2½ by 3/8 inches flat bars are connected to malleable iron lugs bolted to the bottom and sides of the tank. For stiffening, diagonal ribs are pressed into the plates, which are made from a single piece without welds at the corners. There are three kinds of plates to fit the various positions in the tank, but otherwise they are interchangeable. These tanks are made by the American Spiral Pipe Works, Chicago, owners of the American rights of the Piggott patent, and can be furnished in multiples of 4 feet in length or width. Ordinarily, as kept in stock, they are oiled or painted, but may be galvanized.

Test Report of One-Half-Inch Electric Drill

A series of tests was made recently at the University of Cincinnati on a standard ½-inch, 110-volt portable electric drill manufactured by the Standard Electric Tool Company, Cincinnati, Ohio. The data from the test are as follows:

Test No.	Volts	Watts	Size of Drill	Depth of Hole	Time in Seconds	Material
1	95	*	½ in.	2 in.	52	Steel
2	110	450	½ in.	2 in.	67	Steel
3	120	650	½ in.	2 in.	35	Steel

* The watts of the first test varied owing to the varying load on drill, as the feed was too rapid to be regular.

The above tests were made by placing the electric drill in an upright position under the spindle of an upright drill press, and the press feed used to force the drill against the work. Tests Nos. 1 and 3 were made under the most unfavorable circumstances met with in electric drill practice. Test No. 1 was made at a low voltage and the drill was worked extraordinarily hard, and test No. 3 was made at an abnormally high voltage, and the drill again worked much harder than it would ever be possible for it to be worked in actual practice. In either of the above cases the drill was not damaged in the least, either by the high mechancial strains or by overheating. Test No. 2 was made under normal conditions, both as to voltage and load applied to the machine, approximating as nearly as possible to operating conditions where the tool would be in continuous service. The time required to drill a ½-inch hole through 2 inches of steel is quite noteworthy in the above test, as it shows at even the reduced pressure of 95 volts it can be made to drill at the rate of 1 inch in 26 seconds.

Technical Publications

Hendricks' Commercial Register of the United States for Buyers and Sellers. Twenty-first edition. Size, 7½ by 10 inches. Pages, 1,574. New York, 1912: S. E. Hendricks Company. Price, $10.

The twenty-first annual revised edition of "Hendricks' Commercial Register of the United States for Buyers and Sellers" has just been issued. Established in 1891, it has been published annually since that time. Its aim is to furnish complete classified lists of manufacturers for the benefit of those who want to buy as well as for those who have something to sell. It covers very completely the architectural, engineering, electrical, mechanical, railroad, mining, manufacturing and kindred trades and professions. The present is by far the most complete edition of this work so far published. The twentieth edition required 108 pages to index its contents, while the twenty-first edition requires 122 pages, or fourteen additional pages. As there are upwards of 400 classifications on each page, the fourteen additional pages represent the manufacturers of over 5,000 articles, none of which have appeared in any previous edition. The total number of classifications in the book is over 50,000, each representing the manufacturers or dealers of some machine, tool, specialty or material required in the architectural, engineering, mechanical, electrical, railroad, mine and kindred industries. The twentieth edition numbered 1,419 pages, while the twenty-first edition numbers 1,574, or 155 additional pages. An important feature of this commercial register is the simplicity of its classifications. They are so arranged that the book can be used for either purchasing or mailing purposes. The book also gives much information following the names of thousands of firms that is of great assistance to the buyer, and saves the expense of writing to a number of firms for the particular article required. The trade names of all articles classified are included as far as they can be secured.

Lectures on Superheating on Continental Locomotives. By E. Sauvage. Size, 5 by 7¼ inches. Pages, 59. Illustrations, 30. London, 1911: Hodder & Stoughton, Publishers to the University of London Press, Ltd. Price, 5s. net.

The lectures published in this book were delivered at the invitation of the University of London during the month of October, 1910, in the lecture theatre of the Institution of Civil Engineers. M. Sauvage was locomotive engineer of the Western Railway of France before its acquisition by the State, and is the author of standard works on locomotive engineering. He possesses a wide and accurate practical knowledge of recent developments which have taken place on the Continent in this branch of engineering; and, therefore, what he has to say about the development of the superheater for Continental locomotives should prove of value to American readers.

Communications of Interest from Practical Boiler Makers

A Word of Advice

I have been much interested in Mr. Hobart's talks to the boys. He seems to have the capacity of making plain things clear for plain men. College graduates have a faculty for cramming every trifling calculation full of X, Y, Z and other algebraic signs, which may go to show their learning, but Mr. Hobart seems to be able to make himself understood without these signs. I learned geometry and algebra at school, and have used geometry continuously ever since, but have scarcely ever needed algebra. Formulas are very good, but are not plain for beginners. Allow me to say to Mr. Hobart, Go ahead, there is plenty more where that came from, and there is no mystery about boiler making so long as young boiler makers leave liquor alone. WM. J. SILVER.

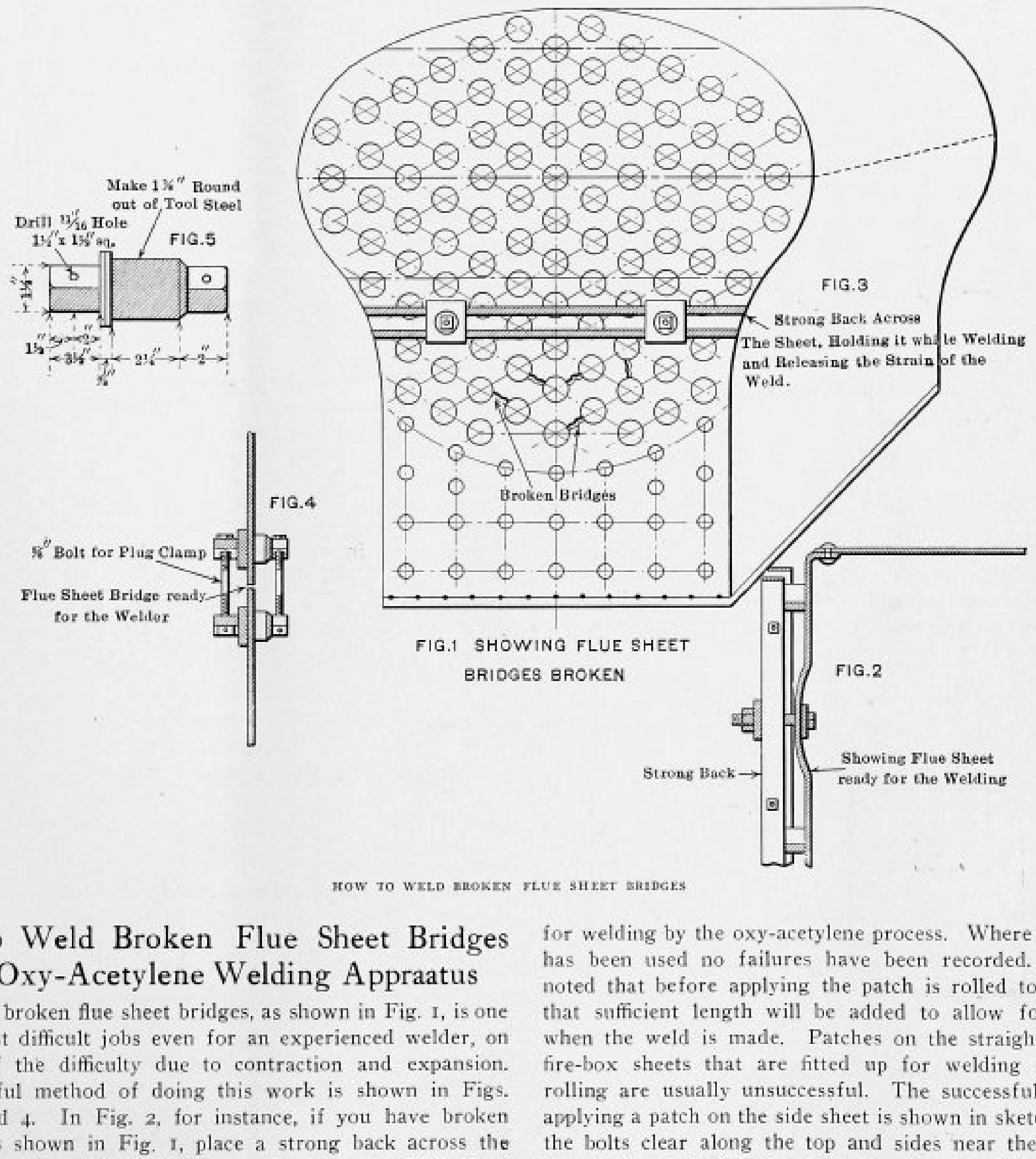
The plug clamps should be kept in the holes until the sheet cools off; then release the strain on the strong back to allow the sheet to come back to its natural position. Fig. 5 shows how the plug clamp should be made.

The writer is also working on another combination clamp with three jaws that can be applied in three minutes to weld flue sheet bridges. This clamp will also take care of contraction and expansion. The clamp is designed for use on the lower holes on flue sheet bridges, where the sheet is more rigid and the strong back will not have much effect.

Albany, N. Y. H. A. LACERDA.

Welding Patches and Side Sheets

The illustration shows what the writer believes to be one of the most successful ways of fitting up patches and side sheets

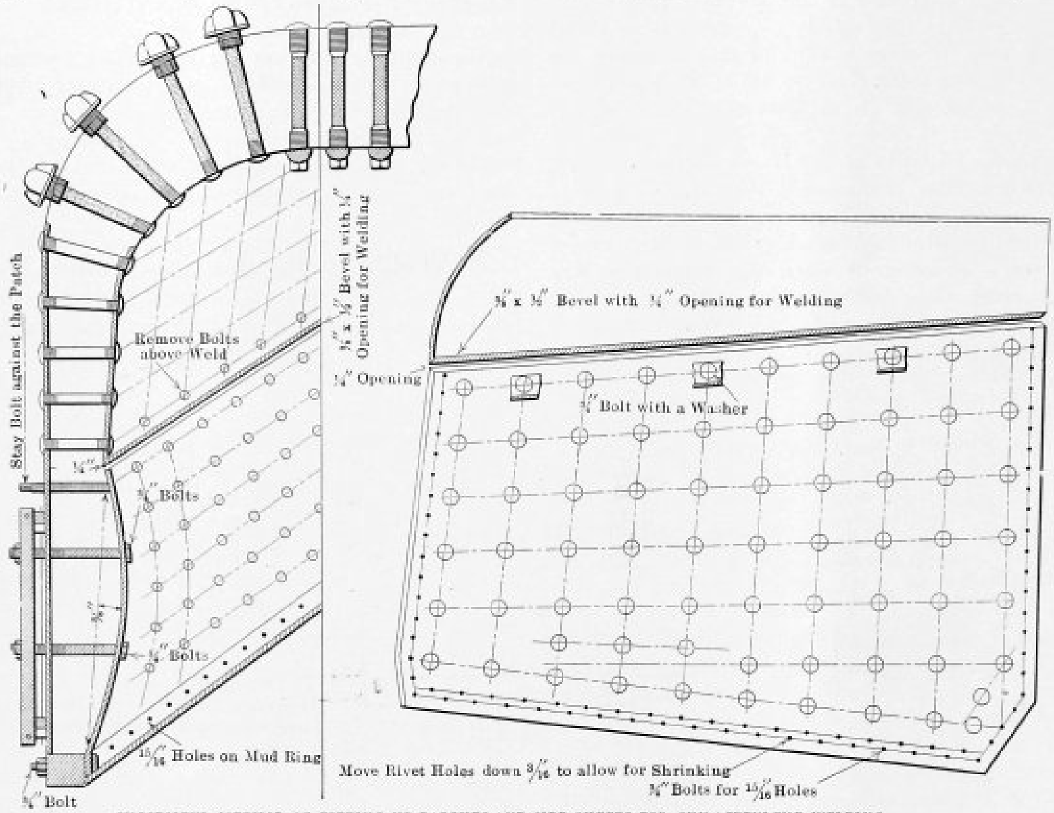


HOW TO WELD BROKEN FLUE SHEET BRIDGES

How to Weld Broken Flue Sheet Bridges with Oxy-Acetylene Welding Appraatus

Welding broken flue sheet bridges, as shown in Fig. 1, is one of the most difficult jobs even for an experienced welder, on account of the difficulty due to contraction and expansion. A successful method of doing this work is shown in Figs. 1, 2, 3 and 4. In Fig. 2, for instance, if you have broken bridges, as shown in Fig. 1, place a strong back across the sheet, and with a ¾-inch bolt draw the sheet out of line 1½ inches. Then place plug clamps with a ⅝-inch bolt, as shown in Fig. 4. As the welding proceeds keep drawing up the bolts a little at a time until the welding is completed. This will draw the weld together at least 3/32 inch; then the expansion will work to the weakest part of the sheet, as shown in Fig. 2.

for welding by the oxy-acetylene process. Where this method has been used no failures have been recorded. It will be noted that before applying the patch is rolled to a curve so that sufficient length will be added to allow for shrinkage when the weld is made. Patches on the straight surface of fire-box sheets that are fitted up for welding without any rolling are usually unsuccessful. The successful method of applying a patch on the side sheet is shown in sketch. Remove the bolts clear along the top and sides near the weld; then lay out the patch for the proper length and width, moving the rivet holes on the mud-ring down 3/16 inch to allow for shrinkage; then roll the patch to some radius that will throw the patch off a proper distance to add about ⅜ inch more than the length required on the flat sheet. When the patch is welded it will be noticed that it will draw 3/16 inch of an inch on each side. Before the patch is bolted up it should be annealed in a blacksmith's fire or in an annealing furnace so as to leave the patch soft. After that the patch should be rolled as described before. Then place a strong back on the outside of the sheet with a ¾-inch bolt to draw the patch in while welding to its natural position. This process will not leave the strain on the weld which is ordinarily caused by contraction and expansion.



SUCCESSFUL METHOD OF FITTING UP PATCHES AND SIDE SHEETS FOR OXY-ACETYLENE WELDING

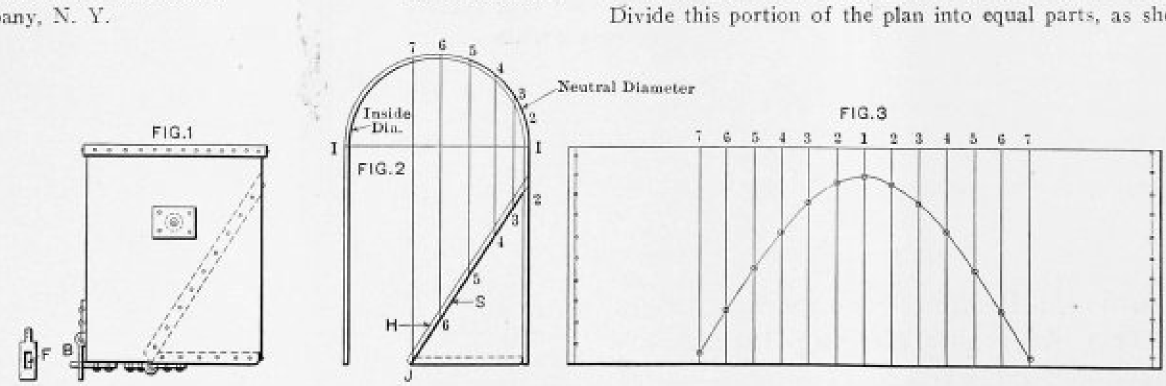
The sketch shows how side sheets should be fitted up for welding. Particular attention should be given to the size of the bolt. The patch should be bolted to the mud-ring so as to have room for contraction. H. A. Lacerda.

Albany, N. Y.

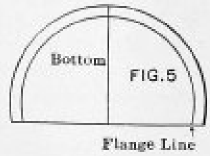
Layout of Buckets

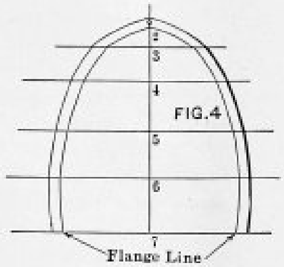
Some time ago, in the railroad shop where I was employed, we had a call for some buckets used in the handling of concrete for foundations of new buildings in course of construction. These buckets were made with a slope plate inside and a narrow drop door at the bottom, with a view to distributing the concrete evenly in the moulds built up for the foundations. Fig. 1 shows an elevation of one of the buckets. The dotted lines show the plate and rivet lines for the slope plate. The drop door was hinged and held in place by catch *B*, which was bolted as at *F*. As this was a somewhat unusual job for a railroad repair shop, it may be of interest to the young men in the shop to know how to develop the plates for such a job.

Erect the elevation of the bucket as at Fig. 2, showing the inside diameter and also the neutral diameter, as this is important in a job of this kind. The thickness of material is shown somewhat exaggerated, so as to show more clearly the various steps in the development. At the top lay out the radius of the inside diameter and the neutral diameter. Now from where the slope plate touches the bottom, as at *J*, square up a line intersecting the radius at the top, as at point 7. Divide this portion of the plan into equal parts, as shown by 7, 6, 5, 4, 3, 2, 1, and from these points drop lines to the rivet and slope lines in the elevation. Line *H* is taken as the rivet line, and line *S* as the plate line. Lay out the circumference as in Fig. 3. Erect the center line 1, and on each side of this line set off the distances found on the neutral diameter, Fig. 2. Drop lines as shown, and on these lines set off the distances taken from line *I-I*, Fig. 2, to line *H* on the similarly numbered lines. A fair curve drawn through these points will give the rivet line. The rivet holes can be spaced to suit, but in this case they should be put in at the points found.



To develop the slope plate, erect a line as at Fig. 4. Along this line set off the various distances taken from line *S*, Fig. 2. From these points set off horizontal lines on each side of the center. Now take the lengths of the lines in the plan from line *I-I* to where they intersect the radius of the inside diameter and set them off on each side of the center lines, Fig. 4, placing them at their respective numbers. A fair curve drawn through the points found will give the shape of the slope sheet. The flange, of course, must be allowed.





As the flanged head for the bottom comes out as a little more than a half circle, it can be set out easily, as shown in Fig. 5. JOSEPH SMITH.

Lorain, Ohio.

Tests of welded joints in boiler plates have been carried out in Germany, where it was shown that the ratio of strength of joint to that of plate could safely be assumed to be .8 instead of .7, as has been specified previously in German regulations. On an average, the strength of a test piece containing a joint was .99 of that of the plain plate annealed, and .98 unannealed. The proportion for the elastic limit was between .85 and .98. Hence the foregoing figures were obtained. The test also showed that the unannealed plates were considerably hardened by overstraining during welding, and that annealing relieves the internal stresses.

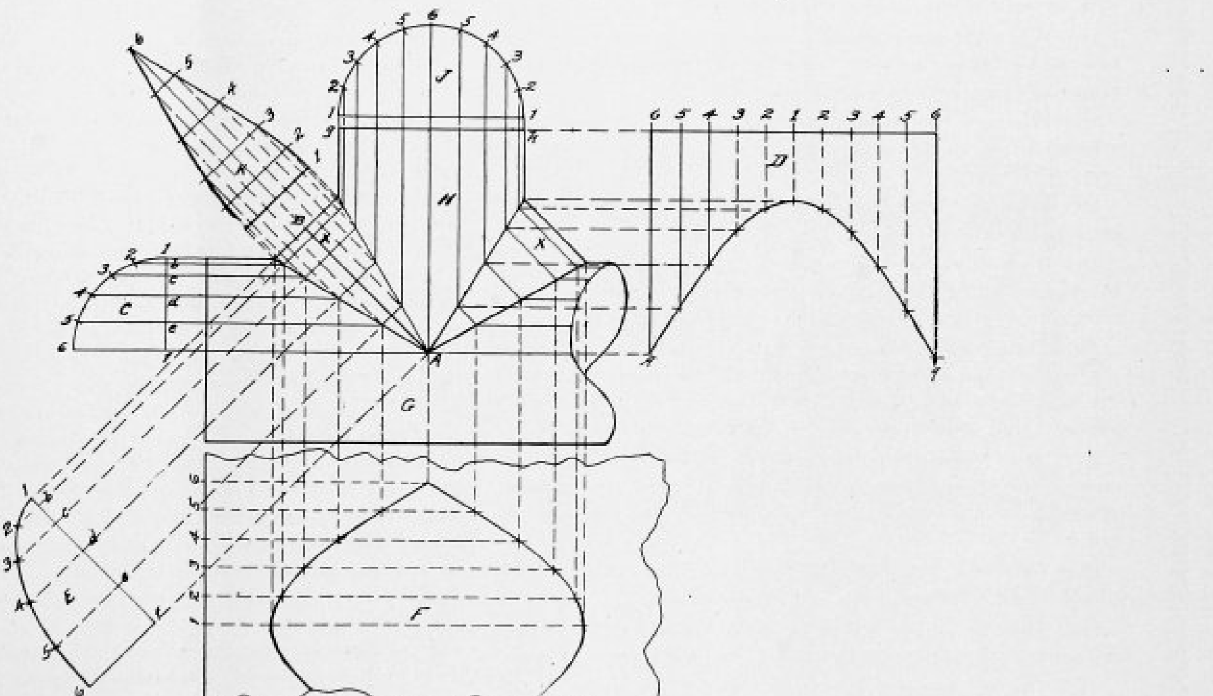
Development of a Cylinder Intersecting a Cylinder and a Gore Piece Intersecting the Two Cylinders

If *H* and *G* are the cylinders and *x* the gore piece, draw semi-circle *J* and quadrant *C*, spacing the quadrant *C* into as many parts as desired. Divide the quadrants of *J* into similar spacing; project these points on *J* and *C* down to the miter lines of *x* and on to *H* and *G*, extending these same lines across the gore piece from points 1, 2, 3, 4, 5 and 6.

In order to secure the plane section of *x*, draw the line *A B* on *x*; extend the lines 1, 2, 3, 4, 5, 6 indefinitely to *E*, drawing at right angles to these lines the line 1, *f*. With distances equal to *b* to 2, *c* to 3, *d* to 4, *e* to 5 and *f* to 6 on *C*, transfer these same measurements to *E* on line 1, *f*. Then an irregular curve through these several points on *E* from 1 to 6 gives us one-half the length of *x*.

To secure the layout of *x*, extend the line *A*, *B* indefinitely to *K*, and at right angles to the line *A*, *B* draw the lines 1, 2, 3, 4, 5, 6, making the distances apart equal to 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6 on *E*. Then project the points of intersection of *x*, *H* and *G*, the dotted lines parallel to *A*, *B* up to and intersecting lines 1, 2, 3, 4, 5, 6 on *K*. Draw an irregular curve through these several points of intersection, and this outline of *K* is one-half the layout of *x*.

To secure the layout of *H* extend the line *g-h* over to *D*, and at right angles to this line draw the equally spaced lines 1, 2, 3, 4, 5, 6, 5, 4, 3, 2, 1, the spaces being the same as on *J*. Then draw lines from the points 1 to 6 on the miter line of *H* and *X* over to and intersecting lines 6 to 1 to 6 on *D*. Draw an irregular curve *A* to *A* through these several points, and you will have one-half the layout of *H*.



To secure the layout of *G*, draw the lines 1 to 6 the same distance apart as the spacing of 1 to 6 on *C*, and with lines at right angles to these lines from points of 1 to 6 on the miter line of *X* and *G*, extended down and intersecting 1 to 6 on *F*, draw a curved line through these points and you have one-half the layout of the cylinder *G* to intersect the gore *x*.

The layout *F* is a little more than one-fourth the circumference of *G*. No allowance has been made for thickness of material, flanges or laps. J. E. BOSSINGHAM.

Questions for Applicants for a Boiler Inspector's Job

The accompanying set of examination questions is a fair sample of those given to candidates for the position of boiler inspector in insurance companies. I submit them to those of your readers who may perhaps aspire to such a position, and by which they may test themselves as to educational fitness as well as to mechanical ability.

Perhaps some of your readers will venture to answer these questions, and so give a number of others the benefit of their knowledge and skill. Let the interested ones get out pencil and pad and get busy on them, and send the answers—with the work—to The Boiler Maker:

Questions

(1) (*a*) How would you proceed to make an internal inspection of a boiler? (*b*) How would you proceed to make an external inspection of a boiler?

(2) How would you determine the safe working pressure of a horizontal tubular boiler 72 inches in diameter, 3/8-inch plate, 13/16-inch rivet hole, 3-inch pitch, assuming 55,000 pounds as the tensile strength?

(3) If the above boiler was of butt-strap construction, and the rivets pitched 6½ inches and 3¼ inches, respectively, and by using a factor of safety of (5), what pressure would you allow?

(4) What pressure would you allow on a fire-box boiler, with 7/8-inch stay bolts pitched 5 inches by 5 inches, assuming the stay-bolt value to be 6,000 pounds per square inch?

(5) What size safety valve would be required on a boiler with 25 square feet of grate? (Give rule.)

(6) What size pump would it require to properly take care of a boiler of 150 horsepower, assuming 30 pounds of water evaporated per hour per horsepower?

(7) Where is the proper place for the feed water to enter a boiler of the horizontal tubular type, the fire-box type, the vertical tubular type?

(8) What is the pressure allowed on a boiler constructed entirely of cast iron?

(9) How would you determine if the segment above the tubes was sufficiently braced, assuming the boiler to be 72 inches in diameter, distance from tubes to shell 24 inches?

(10) Assuming the above boiler to be constructed to carry 125 pounds per square inch pressure, how many braces of the solid crow-foot type, ½ inch by 2 inches, and of 7,500 pounds value, would you require on the head above the tubes?

(11) How would you determine the efficiency of the ligament in the Maxim type of boiler, and how does the ligament efficiency compare with the joint efficiency on this type of boiler?

(12) Where would you attach the water column on a horizontal tubular boiler, also on a fire-box boiler?

(13) Why are tubes beaded on a horizontal tubular boiler, and what is the objection to leaving the ends project at rear?

(14) Do you consider it advisable to flare the tubes in the Maxim type of boiler, and why? Chas. J. Mason.

Scranton, Pa.

A Boiler Inspector's Experience

Your account of the boiler explosion at San Antonio, Tex., attributes it to the combination of a defective steam gage and a locked safety valve. Does it not seem as though anyone who would let such conditions exist is on a par with the fool who "did not know that it was loaded"? This is only one of several similar accidents from the same cause in the past few years, notably at Pittsfield, Mass., and on the M. K. & T. R. R. The latter explosion was identical with the San Antonio disaster, although the loss of life was not so great, but the destruction of property was, and all because some short-sighted official thought he could save a few dollars by placing a worn-out and defective gage on the boiler.

While I was a boiler inspector some years ago, I seldom had less than five or six gages and as many defective or corroded safety valves to report weekly. Two cases I recall particularly, the first of which was in North Dakota. I inspected two of the three boilers, and on trying one under steam pressure to see if the safety valve was free I found I could not lift it. This led me to take the valves off the idle boilers and test them with the feed pump. One valve opened at 205 and the other at 230 pounds, enough pressure to disrupt either boiler. After testing and correcting the gages and slacking off three full turns on the adjusting bolt, the valves were set to operate at a safe pressure. I found on a return visit that the valves would not work at the pressure for which they were set, and no one at the plant knew who readjusted them, as frequent changes were made in the operating crew.

The second case was on a large locomotive boiler in a forge shop in Western New York. This boiler was over a furnace used for heating billets, and supplied steam at 120 pounds to a steam hammer and other units. At the time of my first visit, Sunday morning, I could not get into the fire-box on account of its dirty condition, but I examined the boiler as completely as possible. I reported that the risk should not be carried. The insured would not accept this but arranged to clean out the fire-box and take the dome head off if I would examine it again in two weeks; he felt sure I had made a mistake, as it was a first-class boiler, etc. The following is from the report of the defects found on a re-examination, the external condition having been reported on the first inspection:

"The right side of the furnace has four patches of the following dimensions located at various points on the furnace sheet and all fastened with patch bolts, 15 by 12 inches, 12 by 9 inches, 11 by 8 inches and 12 by 6 inches, also three cracks with a total of eighteen 5/8-inch plugs in them. The left furnace sheet has two patches, 23½ by 11 inches and 16 by 14 inches, also one crack 6 inches long, plugged.

"The back furnace sheet has four patches, 10 by 6½ inches, 10 by 4 inches, 11 by 5 inches and 16 by 6 inches. This sheet is also badly corroded from the furnace door down to the mud-ring, and contains pits from 1/16 to 3/32 inch deep. In the door flange are three patches, 8 by 8 inches, 6 by 4 inches and 8 by 7 inches, also six fire cracks, plugged. The crown sheet has one patch 13½ inches in diameter with two stay-bolts passing through it, and the additional disadvantage that the patch is on the fire side of the sheet. The flue sheet is badly corroded from the lower row of flues to the mud-ring. On the right side of the water leg outside is one patch 6 by 6 inches, and the whole is badly corroded. The joint between this sheet and the front of the water leg leaks, and the left side has one patch 8 by 7½ inches. The back-door sheet shows rivets passing through the mud-ring with the heads nearly all eaten away. Internally the boiler is heavily scaled on the tubes and crown sheet.

"The boiler was given a hydrostatic test, and at 140 pounds pressure the side sheets bulged considerably; at 155 pounds the crown sheet let go in the bracing so that it was impossible to supply the leakage. The steam gage operated in jumps, and showed a variation of from 5 to 30 pounds by the test gage. As this examination bears out the opinion formed of this boiler at the first visit, I recommend that the boiler be replaced at once or the insured dropped."

As the engineer told me the safety valve operated at 120 pounds, I desired to see it do so, so I put no "gag" on the valve. The test gage showed 155 pounds, and when the pump would supply no more water, due to excessive leakage, the valve had shown no signs of blowing. I have found safety valves to stick in the best regulated plants, but as testing them is invariably hot and disagreeable, some engineers take a chance, trusting that when the steam gets to the blow-off point, they can check the draft or put the feed on to hold the pressure down.—*F. J. Nayler in Power.*

Relation of Mechanical Appliances to Fuel Economy

(*Concluded from Page 308*)

Among other mechanical appliances tending toward fuel economy, the feed-water heater must not be overlooked. Prominent among the successful types are the Buck-Jacobs, as used on the Santa Fe, and the Gaines, used on the Central of Georgia. Personal observations, made by the chairman, as to the efficiency of the former, proved that the temperature of the feed-water was increased 75 degrees. This multiplied by the number of pounds of water heated will give the saving in heat units, and this product divided by the number of heat units obtained in the fire-box from each ton of fuel would represent the fuel saving. No absolute data on this particular subject are available, however, but various estimates have placed the feed-water heater, where the temperature is raised 50 degrees or more, as being equal to from 8 to 12 percent.

While the mechanical stoker has a bright future ahead of it, and will unquestionably, when perfected, be applied to such locomotives as consume an amount of fuel beyond the physical capacity of the fireman to handle, yet as a fuel economizer *per se* the committee is not prepared to go on record with any definite statements. Although many tests have indicated that an economy in the amount of fuel per ton mile per hour has frequently been obtained with the different types of stokers, yet other tests have shown contrary results, thereby still leaving the question of economy in pounds of coal somewhat in doubt, but when calculated on the basis of cost per pound of coal the balance is in favor of the mechanical stoker, as tests have proved that by means of this appliance a cheaper grade of fuel can be handled successfully. The committee is prepared to go on record, however, to the effect that on large engines, which tax the ability of the fireman to the utmost, the application of a successful mechanical stoker will result not only in an increased efficiency of the locomotive, but also in a measure of fuel economy.

There are several other mechanical devices, such as mechanically-operated fire-doors, grate-shakers, coal-passers, etc., that have a direct bearing on the fuel problem, but in the absence of any authoritative data on the efficiency of any of these appliances in this respect the committee would prefer to have their relative economies discussed on the floor.

According to the Accident Bulletin No. 43, issued by the Inter-State Commerce Commission, the casualties to passengers, employees and other persons on American railroads in January, February and March, 1912, due to the bursting of, or defects in, locomotive boilers or boiler attachments, are as follows: Passengers killed or injured, none; employees on duty, killed, 41; injured, 263. Employees killed or injured off duty, none; other persons not trespassing, killed, none; injured, 32; other persons trespassing, killed, none; injured, 1; total killed, 41; total injured, 296; total number of persons killed in railroad accidents in the United States from all causes for the above period, 267; total number of persons injured in railroad accidents in the United States from all causes for the above period, 4,785; percentage of those killed by boiler accidents, 15.4; percentage of those injured by boiler accidents, 6.2.

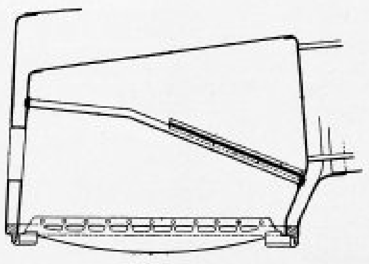
Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,033,953. BAFFLE-WALL FOR LOCOMOTIVE FIRE-BOXES. HARLOW DOW SAVAGE, OF ASHLAND, KENTUCKY.

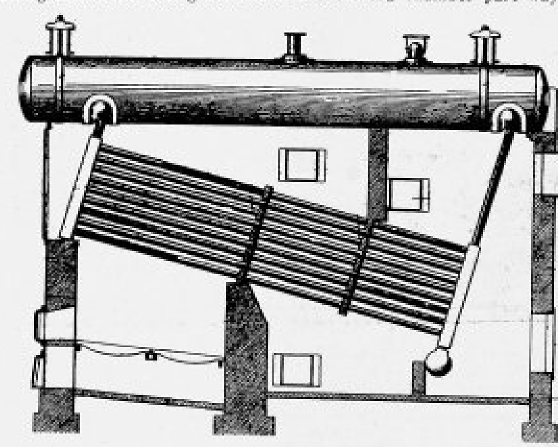
Claim 2.—A locomotive fire box comprising in combination, side walls, longitudinally inclined circulation tubes between said side walls, and a baffle wall on said tubes comprising two opposite rows of like side brick supported at their inner ends and intermediate their ends upon two outer portions extending out to the side walls, said side brick having their inner portions of greater thickness and weight than the outer portions and having a shoulder on their lower faces intermediate their



ends and having the lower inner end corners cut away, whereby portions of said brick extend downwardly between the supporting tubes with the shoulders and cut-away portions abutting against said tubes to prevent lateral displacement of said side brick, and a row of intermediate brick having their lower end edges cut away and resting upon and fitting between the intermediate circulation tubes with portions of said brick extending down between said tubes, said side and intermediate brick being located end to end and being cut away at the upper edges of their facing ends to provide acute facing end edges, and said intermediate brick being adapted to be used either face up and to move laterally and ride upon said side brick during expansion and contraction. Two claims.

1,034,079. STEAM-GENERATOR. ALBERT A. CARY, OF NEW YORK, N. Y.

Claim 1.—The combination of a suitable chamber, a plurality of rows of boiler tubes arranged in said chamber, a baffling member extending transversely of the tubes and dividing said chamber into sections, baffling means extending from one end of said chamber part way along



said tubes, and a second baffling means extending from said baffling member part way along said tubes, said baffling means being arranged so that part of the products of combustion will pass between each baffling means and its adjacent tubes and part will pass around the ends of both of said baffling means. Nine claims.

1,034,084. DAMPER-REGULATOR. NOIBERTO G. COPLEY, OF FOSTORIA, OHIO.

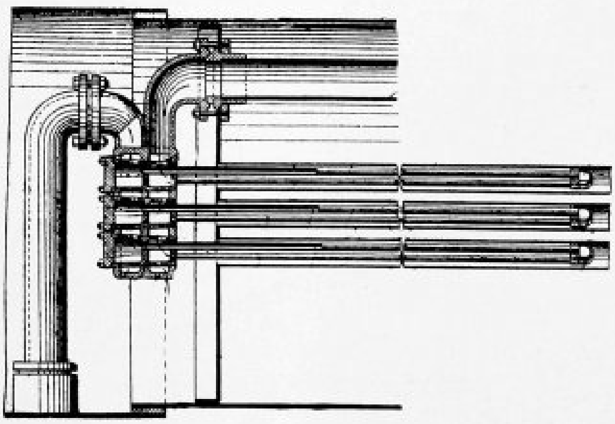
Claim 1.—A damper regulator for steam boilers comprsing in combination, a cylinder having a piston therein adapted to be connected to damper, a pilot valve having a pipe communicating with said cylinder, and having outlet and inlet pipes connected thereto, a weighted arm adapted to be raised and lowered upon variations in the steam pressure, valve members adapted to close said inlet pipe and open said outlet pipe or vice-versa, and a double acting spring operatively connecting said pilot valve members and said weighted arm. Six claims.

1,034,337. STEAM-BOILER. JOHN BARROW, OF COLUMBIANA, OHIO.

Claim 1.—A boiler of the class described, comprising an outer shell, a fire box casing mounted therewithin and spaced from the walls of said shell to form a water space therearound, fire tubes extending from the front wall of said casing to a point adjacent the forward portion of said shell, water circulating tubes having the forward ends thereof mounted in the front wall of said casing and extended loosely through the rear wall of said casing and the rear wall of said shell to points therebeyond, additional circulating tubes disposed below said casing and extending beyond the rear wall of said shell, and means connecting the first and last referred to circulating tubes. Five claims.

1,034,540. SUPERHEATER. SAMUEL M. VAUCLAIN, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO LOCOMOTIVE SUPERHEATER COMPANY, A CORPORATION OF NEW JERSEY.

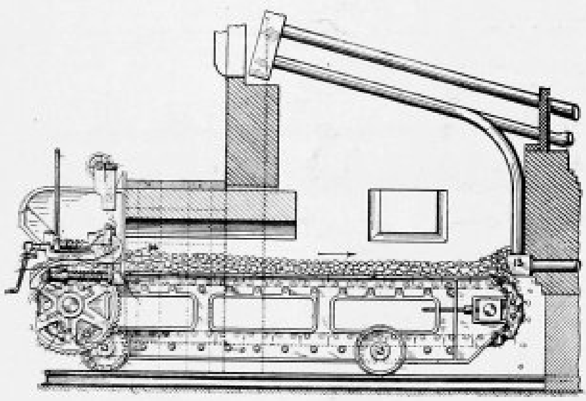
Claim 1.—In a superheater for steam boilers, the combination of a header having a chamber for saturated steam and a chamber for superheated steam, a chambered plug removably secured in the header and having a chamber communicating with the saturated steam chamber of



the header and a chamber communicating with the superheated steam chamber of the header, and a superheater unit having its ends communicating respectively with the respective chambers of the plug. Nine claims.

1,033,952. BAFFLE-WALL FOR LOCOMOTIVE FIRE-BOXES. HARLOW DOW SAVAGE, OF ASHLAND, KENTUCKY.

Claim 2.—A locomotive fire box comprising in combination, side walls, longitudinally inclined circulation tubes between the side walls and laterally disposed in a horizontal plane, and rows of brick on said tubes, the ends of said brick being beveled from their upper and lower faces and of acute wedge-shape, the lowermost brick of each row having a flat side face and being provided with a projection extending beyond the flat



side face of said brick and bearing against the rear side wall, all of said brick being adapted to be placed on said tubes with either the upper or lower beveled faces resting upon and fitting the same and with a portion projecting down therebetween, whereby the inclined faces resting upon said tubes can move laterally and ride upon the upper inclined faces of adjacent brick and contraction and expansion. Two claims.

1,033,192. MECHANICAL STOKER. ERNEST H PEABODY, OF NEW YORK, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

Claim 1.—In a furnace in which the fuel is caused to travel within the combustion chamber, a grate, an abutment at the rear of and in proximity to said grate to provide a restricted outlet for the ash and fuel refuse, and means for moving said grate and abutment relatively to each other to produce a crushing action on the clinkers previous to passing through said outlet. Six claims.

1,034,711. CONTAINER FOR METAL BOILER-CLEANERS. FRIEND A. IVES, OF NEW HAVEN, CONNECTICUT, ASSIGNOR TO THE CONNECTICUT METAL BOILER CLEANER COMPANY, OF NEW HAVEN, CONNECTICUT, A CORPORATION OF CONNECTICUT.

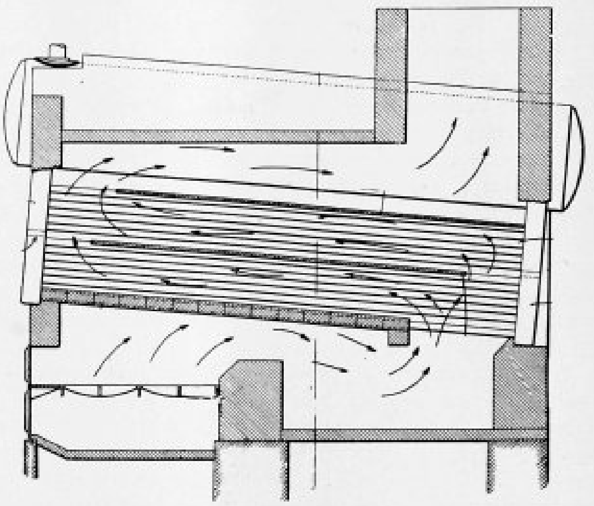
Claim.—The combination with a container, constructed of a single piece of wire, having a body portion formed with parallel coils, the end coils thereof arranged so as to form a removable closure for each end of said container and provide means for securing a plurality of containers together or the container to an independent member; of a metal boiler cleaner, held within said container; and means for suspending said container, comprising a block of non-conducting material connected with said container and constructed so as to be separably connected with a fixed part, whereby if said containers are arranged in series each container will be insulated from every other container in the series. One claim.

1,032,459. STEAM GENERATOR. GEORGE E. WHITNEY, OF BRIDGEPORT, CONN., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE WHITE COMPANY, OF CLEVELAND, OHIO.

Claim 1.—A vapor generating system comprising a reservoir for liquid, a vapor generator composed of coils connected in series and means to heat the same, and conduits extending between a plurality of said coils and the return conduit to said reservoir. Nine claims.

1,032,697. BAFFLE FOR WATER-TUBE BOILERS AND METHOD OF CONSTRUCTING SAME. FREDERICK O. PAHMEYER, OF ST. LOUIS, MO., ASSIGNOR TO HEINE SAFETY BOILER COMPANY, OF ST. LOUIS, MO., A CORPORATION OF MISSOURI.

Claim 1.—A water-tube boiler provided with a plurality of horizontal rows of tubes, baffle members arranged in a horizontal position at one end of said horizontal rows of tubes so as to form a baffle, and means on



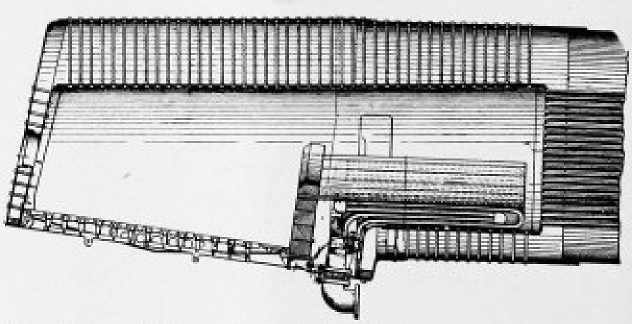
said baffle members for co-operating with devices that are used during the operation of arranging the baffle members in operative position. Six claims.

1,032,711. LOCOMOTIVE EXHAUST PIPE AND SPARK ARRESTER. ROBERT H. SMITH AND BRADWELL CRASWELL, OF MELROSE, MINN.

Claim 1.—The combination, with a boiler having a flue sheet and flues, a smoke-box and a dead plate extending across said box in front of said flue sheet, of an exhaust nozzle having its open upper end projecting through said dead plate, a pipe seated on said dead plate and inclosing the open end of said nozzle, said pipe communicating with the smokestack and provided with an opening in its lower forward walls above the open end of said nozzle, the side and rear walls of said pipe being imperforate, and a spark arrester covering said opening and against which spark arrester the cinders are drawn by the suction of the exhaust past said pipe opening. Nine claims.

1,033,008. LOCOMOTIVE-BOILER FURNACE. JAMES H. GROVE, OF OMAHA, NEB., ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 1.—A locomotive boiler furnace comprising a fire-box having a flue sheet at one end and a fuel door at the opposite end, in combination with a refractory front arch occupying an inclined position back of the flue sheet, and a hollow refractory vertical or crown arch depending



from the top of the fire-box back of said front arch and adapted to direct streams of hot air downwardly beneath said arches and toward the fire. Four claims.

1,035,877. DEVICE FOR COLLECTING SEDIMENT IN STEAM BOILERS. EDWIN P. HEWITT, OF SPOKANE, WASH.

Claim 2.—In a device, a plurality of receptacles separated by a perforated partition, means for supporting the receptacles in a steam boiler, means for admitting water to one of the receptacles and for effecting the discharge of sediment therefrom, such partition acting as a separating device for sediment and a preliminary collecting device, and oil-retaining devices carried by the partition. Seven claims.

THE BOILER MAKER

NOVEMBER, 1912

Steam Boiler Explosions*

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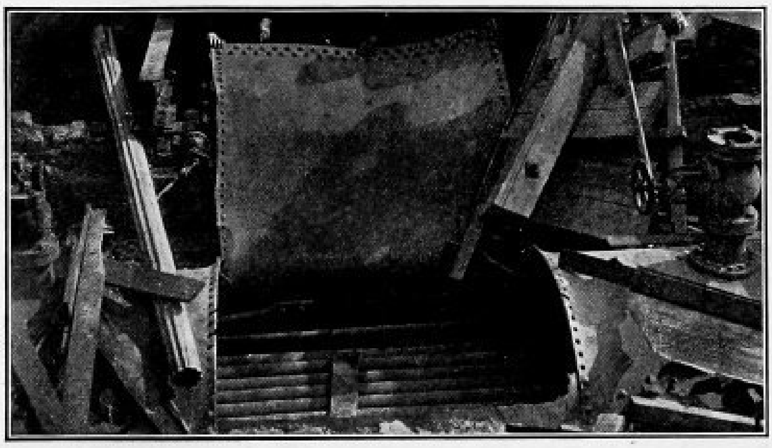
Frequency of Boiler Explosions

Every year there occur in the United States between 1,300 and 1,400 serious boiler accidents, of which 300 to 400 are violent explosions. These accidents kill between 400 and 500 persons, injure 700 or 800 more, and destroy more than half a million dollars' worth of property. In a single explosion, that of the R. B. Grover Shoe Company at Brockton, Mass., 58 persons were killed, 117 more were injured, $250,000 worth of property was destroyed, and an aggregate of $280,000 was claimed in the personal injury and death suits that were brought.



BOILER EXPLOSION, WYOMING VALLEY LACE MILLS, WILKESBARRE, PA. HIDDEN LAP SEAM CRACK

The photographs here reproduced give rather a grim idea of the awful havoc wrought by steam-boiler explosions. They show that these disasters have but scant respect for types—that they occur with water-tube boilers, although with them violent explosions occur less frequently than with fire-tube boilers; that they occur with low-pressure boilers as well as with high-pressure boilers; with fired boilers as well as with unfired steam tanks; with small kitchen boilers as well as with hot-water heaters, and I may add that they also occur even with the ordinary peanut roasters so familiar on crowded street corners.

These facts emphasize: the necessity of constructing and installing steam vessels and their appurtenances in as nearly perfect a manner as possible; the importance of preventing carelessness in their operation; the wisdom of having them inspected at regular intervals by disinterested experts; and the forethought of securing an adequate amount of insurance to pay the loss in case explosion occurs.

Design and Construction

It is of the utmost importance that boilers be carefully designed, that the stresses to which they are subjected be accurately computed, that suitable material be specified, that the material be critically examined for flaws or defects, that specimens of the material be tested to determine its strength, that no abuse of the material be allowed in the process of constructing the boiler, and that the completed boiler be subjected to a thorough inspection and a hydrostatic test before being put into service.

Stress in Girth and Side Seams

The stress in the girth seams of a boiler may be obtained by the formula

$$S = \frac{rp}{2t}$$

in which S is the stress per square inch to which the material is subjected, r the radius of the boiler, p the steam pressure carried, and t thickness of the shell. Stated in words the formula means that if we multiply the shell radius by the steam pressure, and divide the product by twice the shell thickness, the result will be the stress in pounds per square inch to which the material in the girth seams is subjected.

The stress in a side seam of a boiler may be obtained by the formula

* A lecture delivered at Cornell University before the student branch of the American Society of Mechanical Engineers, May, 1912.

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$$S = \frac{r p}{t}$$

which stated in words means that if we multiply the shell radius by the steam pressure and then divide the product by the shell thickness, the result will be the stress in pounds per square inch to which the material in a side seam is subjected.

If it so happens that the efficiency of the girth seam is too low by reason of improper design, then the girth seam may fail instead of the side seam as assumed above, in which case the bursting pressure is given by the formula

$$P = \frac{2 t s}{r} e'$$

BOILER EXPLOSION, GREENWICH COLD STORAGE CO., NEW YORK, N. Y. TUBES IMPROPERLY ROLLED IN TUBE SHEET

An inspection of these formulæ shows that the stress in a side seam is just twice as great as the stress in a girth seam. It is for this reason that the side seams are usually double riveted when the girth seams are only single riveted.

Bursting Pressure

The pressure required to rupture the shell of a cylindrical boiler is given by the formula

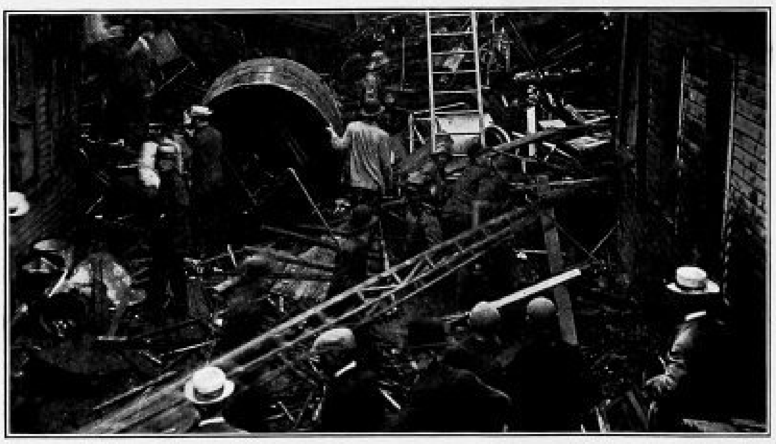
$$P = \frac{s t}{r} e$$

in which P is the bursting pressure in pounds per square inch, s the tensile strength of the material in the boiler, r the radius of the shell, and e the efficiency of the riveted side seam. Stated in words the formula means that if we multiply together the tensile strength of the material, the thickness of the shell, and the efficiency of the riveted side seams, and then divide the product so obtained by the radius of the shell the result will be the steam pressure at which explosion will occur.

which stated in words means if we multiply together twice the thickness of the shell, the tensile strength of the material, and the efficiency (e') of the girth seam, the result will be the steam pressure at which explosion will occur. It is to be observed, however, that the girth seam is not likely to fail before the side seam, because to do so the efficiency of the girth seam would have to be less than half that of the side seam—a weakness that should not exist in a boiler of proper design and construction.

Factors of Safety

It is particularly to be observed that the formulæ expressed above give the pressure at which the boiler will explode and not the pressure at which it may be safely operated. It is usual in boiler practice to fix the allowable working pressure for a new boiler at *one-fifth* the computed bursting pressure and to decrease the pressure allowance as the age of the boiler increases.



BOILER EXPLOSION, LAKEPORT STEAM LAUNDRY, LACONIA, N. H. 1 KILLED; 7 INJURED; PLANT WRECKED. OLD BOILER; DEFECTIVE MATERIAL

This is equivalent to saying that the factor of safety applied to a new boiler is usually not less than *five*. The term "factor of safety," however, is so often misunderstood that I have thought a better name for it would be "factor of ignorance." It really is as much a factor of ignorance as it is a factor of safety.

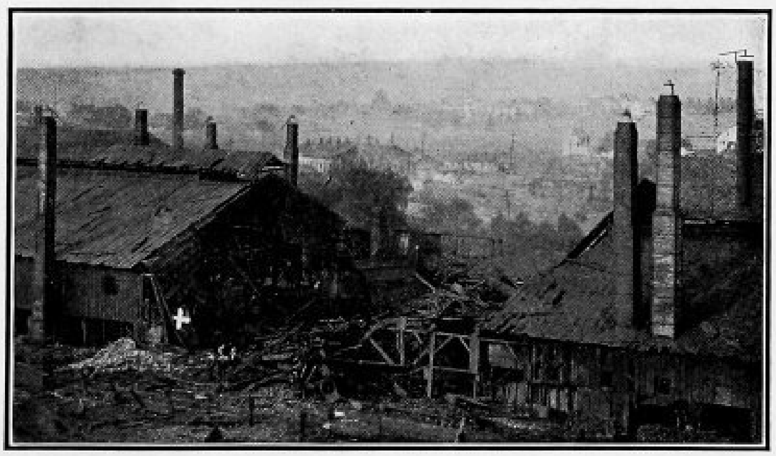
Take, for example, the case of a new boiler operated with the safety valve set at 100 pounds. If the computed bursting pressure be 500 pounds, then the assumed factor of safety is *five*. The assumption, however, is based upon the tensile strength stamped in the plate by the steel maker, and this strength is only true of that particular part of the plate from which the test specimen was cut and not necessarily true of any other part.

As a matter of fact, it is current practice to cut the test specimen from the outer edge of the plate, and the strength there is almost invariably greater than the strength at the center of the plate. The reason is that after liquid steel is poured into a mold its solidification in forming an ingot proceeds in much the same manner as does the solidification of water in forming a block of ice. That is to say, the impurities and gases are driven toward the center, as almost every one has observed when looking through a clear block of manufactured ice. Boiler plates made by the rolling of such an ingot will, therefore, have more impurities and less strength at the center of the plate than at the outer edges, and this variation in strength is very considerable. Then, too, it should be borne in mind that the stress at which the elastic limit of the material is reached is little more than *half* the stress at which rupture occurs.

Besides our ignorance of the dependable strength in all parts of the plate, there is also our ignorance of the character of the workmanship in the boiler. We cannot be certain that all rivet holes come fair, or that incipient cracks have not been set up by an abuse of the material during the process of construction.

It is seen, therefore, that factors of safety are really made up of two parts—one part a true factor of safety, the other a pure factor of ignorance. If this matter were better understood, boiler owners would themselves insist upon a computed factor of safety of not less than five and they would not be so persistent, as many are, in demanding that their boiler insurance company grant an unwise increase of pressure.

BOILER EXPLOSION, ROBINSON CLAY PRODUCTS CO., MIDVALE, OHIO. 2 KILLED; PROPERTY LOSS, $24,000. BOILER CONNECTED TO BATTERY WHEN PRESSURE WAS DIFFERENT



BOILER EXPLOSION, SUSQUEHANNA IRON & STEEL CO., YORK, PA. 9 KILLED; 20 INJURED; PROPERTY LOSS, $150,000. UNINSURED BOILER HAD NO WATER OR STEAM GAUGE AND SAFETY VALVE STUCK

Causes of Boiler Explosions

Boiler explosions may be attributed to improper construction, improper installation, or incompetent or careless operation.

Improper construction may consist: Of unsuitable or inferior material; poor workmanship; abuse of material, as when unmatched rivet holes are drift-pinned to place, or uncylindrical shells are sledged to form; of employing the more dangerous lap-joint for the side seams instead of the more safe and more sensible butt-joint, etc.

The lap-joint is dangerous because this form of construction promotes the formation of incipient cracks in the upper surface of the lower lap where they may be impossible of detection. These cracks extend from rivet hole to rivet hole and gradually deepen with the continued raising and lowering of the steam pressure until the metal, no longer capable of resistance, gives way and causes a violent explosion.

The lap-joint is given the preference over the butt-joint solely because it appears at first thought to be cheaper. Its labor cost doubtless is lower, but its lower efficiency makes necessary the employment of thicker plates to withstand the required steam pressure; and so the greater cost of the material, together with the heavier freight charges, really makes the lap-joint the more costly of the two. There is, therefore, no excuse for its existence, and its employment in the construction of new boilers should be prohibited by law in all States, as it now is in some.

Improper installation may consist of so supporting the boiler and its piping as to allow temperature changes to set up dangerous stresses in the material, of improperly attaching the usual appurtenances, such as safety valves, steam and water gages, check, blow-off, and stop valves, etc.

Incompetent or careless operation may consist in allowing the steam gage to get out of order, in allowing the water-gage connections to become so clogged as to indicate ample water when there is none in the boiler, in allowing the safety valve to become so stuck to its seat as to fail to blow at the pressure for which it was set, in allowing grease to enter or scale to accumulate in the boiler, in allowing large quantities of cold water to be impinged against hot plates, in allowing the water to be driven from the heated surfaces by forced firing, in allowing a large valve to be opened too suddenly, in allowing two boilers to be cut in on the same steam main when their pressures are unequal, and in allowing minor repairs to be neglected until they endanger the whole structuree.

It is significant that many violent boiler explosions occur either just prior to the starting of the engines in the morning, or while they are idle at the noon hour, or shortly after they have been shut down for the day. The reason is that when steam is not being drawn from the boiler it accumulates rapidly; and if the safety valve fails to relieve the pressure, explosion soon follows.

The rapidity with which the bursting pressure is reached may be shown as follows:

Let T equal the time in minutes required to reach the bursting pressure, W the weight of water in the boiler, t the temperature of the steam at bursting pressure, t' the temperature of the steam at normal working pressure, and U the number of heat units per minute supplied by the furnace and absorbed by the water. The heat balance is then represented by the equation:

$$UT = W(t - t')$$

$$T = \frac{W}{U}(t - t')$$

which stated in words means that if we multiply the difference between the temperature of the steam at bursting pressure and at normal pressure by the weight of the water in the boiler, and then divide the product by the number of heat units supplied per minute by the furnace, the result will be the number of minutes that will elapse from the time the openings are all closed until explosion follows.

Take, for example, a 100 horsepower horizontal tubular boiler containing at normal level 10,000 pounds of water, and suppose it uses 50,000 heat units per minute when evaporating 50 pounds of water per minute. Then if the normal gage pressure be 85 pounds, the corresponding temperature of the steam is 327 degrees, and if the bursting gage pressure be 485 pounds, the corresponding temperature of the steam is 467 degrees; and the time required to reach the bursting pressure with all steam openings closed and the safety valve stuck is:

$$T = \frac{10{,}000}{50{,}000}(467 - 327) = 28 \text{ minutes.}$$

That is, with a stuck safety valve, only 28 minutes would elapse from the time the engines were shut down until the explosion followed.

Explosive Energy in Heated Water

The temperature of the water in a boiler is approximately the same as the temperature of the steam with which it is in contact. If the fire be drawn when the openings are closed, ebullition ceases. If a valve be opened, ebullition starts again, even though there still be no fire under the boiler.

It is plain, therefore, that with the openings closed it is the pressure on the surface of the water that prevents further generation of steam. It is also plain that if a small rupture occurs below the water line a violent explosion may not ensue. But it ought to be evident that if a large outlet above the water line be suddenly opened, as, for example, when a steam-pipe fails, then the sudden liberation of the pressure on the surface of the high-temperature water will allow it to flush suddenly into steam and cause a violent explosion and water-hammer that will disrupt the strongest possible construction.

It is in this manner that most violent explosions are produced. The violence is incomprehensible to the layman who sometimes jumps to the conclusion that dynamite instead of steam caused the disaster. There is, however, no warrant for such a conclusion. A cubic foot of heated water under 60 to 70 pounds pressure contains about as much stored-up energy as a pound of gunpowder; and it has been estimated that the heated water in an ordinary cylindrical boiler contains enough energy to project the boiler to a height of two miles!

Grease in Boilers

The action of grease in a boiler is peculiar. Grease does not dissolve or decompose in water, nor does it remain on the surface. Heat in the water and its violent ebullition cause the grease to form in sticky drops which adhere to and varnish the metal surfaces of the boiler. This varnish, by preventing the water from coming into intimate contact with the metal, prevents the water from absorbing the heat, and this causes a blistering or burning of the plate that often results in a serious rupture or a violent explosion.

Scale in Boilers

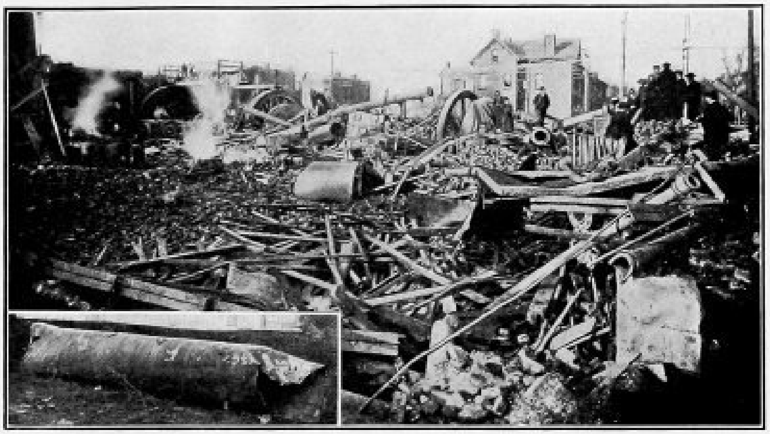
If scale is allowed to accumulate to any considerable thickness in a boiler, a bag or rupture of the boiler is inevitable, unless, perchance, the scale happens to be of a spongy formation, which is not often the case. Just why this is so is shown by the following simple experiment.

Take an ordinary granite iron or tinned iron stewpan and firmly glue to its underside a postage stamp. Pour water into the pan and place it on a gas stove so that the postage stamp will be in direct contact with the flame. Leave the pan on the stove until the water has boiled violently and then examine the stamp. The stamp will not even be charred, much less burned. In fact, it may be removed from the bottom of the pan and used to post a letter in the regular way. And this, notwithstanding the fact that it was on the underside of the pan and in direct contact with the hottest part of the flame.

Now put into the pan a mixture of water and Portland cement half an inch thick. This, when set, will be the equivalent of half an inch of scale. Repeat the experiment made before and it will be found that the stamp will burn up very quickly.

The reason that the postage stamp on the bottom of the vessel is not charred by the flame when no scale is present is that the water, being in immediate contact with the thin bottom of the vessel, absorbs the heat as fast as it is put into the vessel by the flame. The result is that, no matter how hot the flame may be, the bottom of the vessel remains at practically the same temperature as the boiling water with which it is in contact. In an open vessel the temperature of boiling water, of course, is 212 degrees, and this is not sufficiently high to char paper. When scale is present, the water cannot absorb the heat as fast as it is put into the vessel by the flame, as a result of which the temperature becomes greater than 212 degrees and burns the postage stamp.

It is the same with steam boilers. If the water comes in direct contact with the thin plates, the heat is absorbed, the temperature of the plates remains practically the same as the water, and no harm is done. If there be a considerable thickness of impervious scale in the boiler, the water cannot absorb the heat as fast as it is put into the plates by the furnace, and so the plates become overheated, get red, become plastic, and finally give way to the force of steam pressure, causing a bag, or a rupture, or a violent explosion of the boiler.



WATER-TUBE BOILER EXPLOSION, ST. LOUIS TRANSIT CO. 7 KILLED; 19 INJURED; PROPERTY LOSS, $112,000. CAUSE, BREAKAGE OF STEAM HEADER

Scale endangers the safety of boilers in other ways. It clogs the feed pipes, preventing the feed water from freely entering the boiler. It clogs the connections to the water-gage, causing it to indicate ample water when none at all is in the boiler. Pieces of it get under valves and prevent their closure. A blow-off valve, for instance, screwed down hard and thought to be shut, recently allowed all the water to leak out of the boiler, and caused its burning into a mass of warped plates and bent tubes unfit for further use. Then, too, scale decreases the efficiency and increases the fuel consumption of the boiler.

Scale in boilers, therefore, is a serious matter. In order to prevent its accumulation, it is good practice to eliminate the scale-forming matter from the feed water before allowing it to enter the boiler. This can be accomplished either mechanically by means of separators, or chemically by treating the water in vats especially arranged for the purpose. If preferred, compound may be fed with the water into the boiler, but in such case the water should be analyzed, and the proper compound prescribed by a chemist making a specialty of such matters. Kerosene fed into the boiler has proven beneficial in many instances.

Inspection and Insurance

It is an almost universal custom for boiler owners to have their boilers insured and inspected. The insurance serves as a guarantee that the inspections will be intelligently and carefully made and the inspections lessen the chance of accident.

When boiler insurance is carried, an inspector of the insurance company visits the plant at regular intervals. He critically examines the boilers, both internally and externally, hammer-testing them thoroughly in order to discover defects or weakness. If he finds oil or scale in the boiler, a remedy is prescribed to eliminate it and to prevent re-accumulation. He notes the exact condition of the boilers and secures all data necessary to determine the maximum steam pressure at which they are safe. He examines the brick setting, tries the safety valves, tests the water gages, and standardizes the steam gages by comparing them with his standard test gage. And he inspects the piping, injectors, feed pumps, and other apparatus auxiliary to the boiler.

Immediately upon completing his examination, the inspector makes a verbal report to the owner of the plant, and sends a written report to the insurance company. The insurance company then renders a written report to the owner confirming the verbal report already delivered by the inspector.*

The value of this system is reflected in the experience of The Fidelity and Casualty Company, the inspectors of which during the past ten years made 1,101,140 examinations and reported 140,989 defects, many of which consisted of dangerous fractures in or near the riveted seams. It is significant that one boiler out of every eight examined contained defects serious enough to warrant their being reported.

Many States wisely have passed laws providing for the examination and licensing of stationary engineers, and for the compulsory inspection of steam boilers. Such laws very properly exempt from State inspection boilers inspected by boiler insuring companies. One of the best of these laws is the Massachusetts law. It has been used as a model by the State of Ohio and by other States.

Unfortunately the State laws are not uniform. A boiler built in accordance with laws of one State may be rejected if shipped into an adjoining State; and a State that has no such law may become the common dumping ground for old, worn-out, and dangerous boilers rejected from a State that has such laws.

Uniform laws are, therefore, greatly to be desired, and in an effort to secure uniformity, the American Society of Mechanical Engineers has appointed a Commission to prepare a standard code for the construction and safe operation of steam boilers. This commission consists of Mr. John A. Stevens, consulting engineer, Prof. R. C. Carpenter of Cornell, and Prof. E. F. Miller of the Massachusetts Institute of

* The system here described is that of The Fidelity and Casualty Company.

Technology, representing the steam users' interest; Mr. C. L. Huston, representing the steel manufacturers' interest; Mr. H. C. Meinholtz and Mr. Richard Hammond, representing the boiler manufacturers' interest; and Wm. H. Boehm, of The Fidelity and Casualty Company, representing the boiler insurance interest.

The commission is now engaged in the preparation of this code. When it is completed, it is hoped that steam users will want, and manufacturers will build, their boilers in accordance with the A. S. M. E. standard; that the States will adopt it as their standard; and that eventually complete uniformity will thus be brought about.

Chemically Treated Water and Increased Locomotive Efficiency*

The committee reports that the use of soda ash in the tank in the proportion of about 1 pound per 1,000 gallons, the use of caustic soda in smaller proportions, and also the water-treating plants, have all met with success so far as scale formation is concerned. In connection with the graphite, luminator and crude oil treatments, the committee has no information of any beneficial results having been obtained.

But one complete report was submitted in reply to the request for the cost of treating feed-water. This was from the Santa Fe. The accompanying table gives the average costs for the different divisions:

COST OF TREATING WATER ON THE SANTA FE.

STATION.	GRAINS OF INCRUSTANTS.			Lbs. Incrustants Removed Per 1,000 Gals.	Cost Per 1,000 Gals.	Total Lbs. Incrustants Removed.
	Before Treat.	After Treat.	Removed.			
Illinois Division	29.2	3.6	25.6	3.65	.0313	972,193
Missouri Division	25.7	4.4	21.3	3.04	.0210	470,463
Kansas City Division	20.7	4.8	15.9	2.27	.0230	595,491
Eastern Division	28.4	4.0	24.4	3.48	.0282	1,073,922
Middle Division	36.9	4.3	32.6	4.65	.0444	1,100,651
Oklahoma Division	34.3	4.3	30.0	4.28	.0319	808,954
All Eastern Lines	30.8	4.2	26.6	3.80	.0298	5,021,674
Western Division	33.8	2.9	30.9	4.41	.0425	654,506
Arkansas River Division	52.4	3.6	48.8	6.97	.0553	1,596,271
Colorado Division	47.8	3.5	44.3	6.32	.0231	894,667
New Mexico Division	42.9	4.3	38.6	5.51	.0186	1,006,544
Rio Grande Division	24.3	4.1	20.2	2.88	.0311	648,573
Pan Handle Division	42.4	3.3	39.1	5.58	.0432	427,695
Plains Division	31.4	4.2	27.2	3.88	.0182	41,853
Pecos Division	39.2	3.8	35.4	5.05	.0611	956,886
All Western Lines	38.9	3.7	35.2	5.02	.0375	6,226,995
A., T. & S. F. Proper	34.9	3.9	31.0	4.42	.0336	11,248,669
Albuquerque Division	34.1	4.2	29.9	4.27	.0393	1,152,635
Arizona Division	25.0	3.2	21.8	3.11	.0257	1,271,690
Los Angeles Division	23.6	2.5	21.1	3.01	.0274	1,042,723
Valley Division	22.6	2.9	19.7	2.81	.0261	171,916
Coast Lines	26.3	3.2	23.1	3.30	.0297	3,638,944
A., T. & S. F. System:						
1911	30.6	3.5	27.1	3.87	.0324	14,887,633
1910	31.6	3.6	28.0	4.00	.0318	15,284,164
1909	35.4	3.7	31.7	4.52	.0332	13,063,320
1908	35.8	3.9	31.9	4.55	.0346	11,102,859
1907	32.6	4.3	28.3	4.03	.0355	9,579,772
1906	35.0	4.1	30.9	4.41	.0361	7,906,233

The conclusions from the answers to the questions in connection with the mileage of flues and fire-boxes before and after treatment of feed-water show that an increase in mileage of from 78 percent to 150 percent is being obtained where the water is handled in treating plants. Equally good results followed the use of anti-scale chemicals in the tenders. Following is the report of the Santa Fe on this feature:

"Since the adoption of our water-treating system the mileage of fire-boxes and flues has been doubled and trebled. One of the best examples is the Los Angeles division. In the latter part of 1905, eight large Pacific type oil-burning, passenger locomotives went in service on that division, and up to December, 1907, each of these locomotives had received a new fire-box, six of them had received three sets of flues, and the other two, two sets; the average mileage of all fire-boxes was 66,064, the lowest 62,452, and the highest 81,608. The average mileage per set of flues during this period was 25,167. There are mountain grades on which helpers are used. The work performed by these engines is heavy fast passenger service, and a very large part of the division is 1 percent grade. Shortly after these engines received new fire-boxes, or in the latter part of 1907 and the beginning of 1908, a number of water-treating plants was installed and three other plants were installed in 1910, consequently some of the locomotives made considerable mileage with the second fire-box before the installation of the water-treating plants was completed. There are no serious defects in these boxes yet, and they have up to January of this year given an average service of 168,589 miles, and are still going; the flues have given an average service of over 44,000 miles, an increase in flue mileage of 78½ percent.

"We use treated water to prevent incrustation, and give credit for the prevention of incrustation and improvement in the performance of our fire-boxes and flues to the system of treating water. We use an anti-foaming treatment to prevent foaming, both with our treated water and in territories where the water is not treated, which does the work very satisfactorily, eliminating all of the troubles due to a foaming boiler, reducing the cost of fuel and lubrication, and enabling us to handle tonnage that it would be impossible to handle otherwise. In territories where the water is not bad enough to warrant the installation of treating plants, but does give trouble with foaming, we find that anti-foaming preparations have a favorable effect in preventing incrustation as well. It is but just and fair to a water treatment that counteracts or prevents foaming, to give it credit for adding to the life of the fire-box and flues, on the theory that when it prevents foaming it keeps the water in a more dense condition, so that it absorbs more readily the heat that is passing through them, and by so doing prevents their overheating and consequent damage."

Other conclusions reached by the committee were that treated water increases the tendency to foam; that anti-foaming chemicals are successful; that treated water does not increase the mileage between washouts; that the efficiency of the locomotive is increased by the use of treated water, especially if used in connection with an anti-foaming treatment; that the increased foaming of waters treated for scale increases the cost of maintenance of the locomotive; that blow-off cocks should be freely applied and used, that their operation should be convenient and that the frequent use of blow-off cocks for short intervals is better than longer openings at long intervals. The committee stated that soda ash is beneficial in waters where the encrusting solids are heavy and the alkali salts light.

According to a newspaper report there were only two engine failures on the Oklahoma division of the Santa Fe Railroad in the month of June. Neither failure was the fault of the boiler department, but happened in the machinery, and both failures were unavoidable. This is probably the best record on the system. It is due to the team work that is in constant practice by the employees of the Santa Fe shops in Arkansas City. In April and June there were no boiler failures charged to the Oklahoma division, and this is a brilliant piece of work that is rarely accomplished on any division of the Sante Fe, if it is accomplished at all.

* Committee report read before the Traveling Engineers' Association, Chicago, August, 1912.

Smoke Abatement as Related to Steam Railroads*

BY WILLIAM A. HOFFMAN†

The elimination of smoke caused by the railroads is the most difficult of all problems of smoke abatement. Not only does this apply to St. Louis, but it is the opinion of all the smoke inspectors of all our large Western cities where bituminous coal is burned.

Prof. Breckenridge, in his excellent address of February, 1908, before the St. Louis Railway Club, on "How to Burn Bituminous Coal in Boiler Furnaces Without Smoke," after describing the success in burning bituminous coal in stationary plants, said: "No attempt has been made in this article to discuss the problems of smoke prevention in such important types of boilers as the locomotive, or in house-heating boilers. It is hoped, however, that information may very soon be available that will tend to great improvement in the smokeless burning of bituminous coal in these types of boilers."

The locomotive type of boiler, portable or stationary, regardless of the service rendered, presents numerous difficulties in the way of elimination of smoke.

The bituminous coal consumed in St. Louis in 1910 was 7,598,394 tons. Of this 1,813,000 tons, or 23.8 percent, was used by the railroads. It is therefore necessary that the railroads, being consumers of such a large percent of the bituminous coal, must make special effort in applying smoke-preventing devices on locomotives, together with careful operation of these devices and careful firing of coal, if it is their desire to co-operate with the city in its efforts for smoke abatement.

The smoke from locomotives is objectionable because it is discharged into the atmosphere at a low elevation. This is in marked contrast to the smoke of industrial plants, which is discharged into the atmosphere at an elevation of 50 to 150 and 200 feet. The railroads labor under two disadvantages. First, that of burning bituminous coal in the locomotive firebox, which is one of the most difficult places to apply and maintain a smoke-abating device, and second, that of discharging the smoke from the stack at a low elevation.

In the city of St. Louis there are being operated 460 locomotives, 190 in passenger service, 102 in freight service and 168 in switching service. The greatest violators are the switching locomotives, which constitute 37 percent of the total.

There have been more smoke-abating devices installed on locomotives during the past year than at any previous corresponding period. This was due to the desire of those in charge of the smoke-abatement work of the city that the railroads co-operate with the department and equip all their locomotives with devices.

The roads entering and operating in St. Louis vary in locomotives operated from 1 to 134. The variation in percent of devices installed to total is 0 to 100 percent; the average being 38 percent. The roads doing switching work have wisely equipped nearly all of their switching engines with devices. The records of the department indicate that the percentage of smoke violations is proportional to the percent of devices installed.

The department of smoke abatement in estimating the relative blackness of density of smoke uses what is known as the Ringlemann method, the standard adopted by the United States Geological Survey in all the large cities of this country. The reports by inspectors of all observations are entered on printed forms and filed in the office for record, and a copy of each violation is sent to the master mechanic or superintendent of motive power of the road committing the offense.

The report gives in detail the road to which the locomotive belongs, its number, date and where the violation occurred, the point of observation, the total time of observation, the number of minutes of dense smoke emitted during that period, and the service indicated, such as passenger, freight or switching.

The reports are such that the officer receiving them can make an investigation of the violation, which he usually does by demanding of the engine crew a cause for the complaint.

The department has been reporting violations to all the roads since Jan. 2, 1912. During the month of January there were 1,222 observations made and 534 violations reported; during the month of April there were 1,270 observations made and 327 violations reported. The percent of violations to observations was 43.7 in January and 25.4 in April.

In addition to encouraging the installation of devices the department has found by experience that there must be constant inspection. Our inspectors note an approaching locomotive discharging large volumes of dense smoke into the atmosphere; the engine crew, seeing the inspector, usually "cut the smoke." Carelessness of this kind can only be reduced by constant inspection. As proof of this we have noted that when observations have been made daily for a thirty-day period, the ratio of violations to observations made decreases remarkably with the length of the daily observation period.

The locomotives operating in and about St. Louis are equipped with various smoke-abating devices. Some have only the stack blower; others have several steam-impelled air jets entering either from in front on each side of the fire door or from the sides of the fire-box; while others have the jets and in addition an arch of firebrick material, which extends from the front tube sheet toward the front over the fire. There are some superintendents of motive power who claim that the equipment of smoke-abating devices is unnecessary and that careful firing will accomplish the purpose.

It is my opinion that satisfactory results will not be obtained until every locomotive is equipped with a substantial smoke-abating device. This has been found necessary in our manufacturing districts, and I know of no reason why the results of that experience should not apply to railroads.

There are too many variables in the "careful firing method" to warrant it of itself being classified as a substantial smoke-abating device.

Careful and regular firing should be done at all times. It has been the practice in the past to fire ten or twelve scoops of coal at a time. This amount of coal chilled the fire, reducing the temperature, and prevented the air from having a free entrance to the fire-box through the grates at the very time it is so essentially necessary to assist in the combustion of the coal. The result was a long trail of dense smoke, which continued until the fire burned sufficiently to obtain a high fire-box temperature and enough air found its way through the burned fuel to supply the gases generated; at this point we had perfect combustion of the coal—hence no smoke.

The engine crew are in control, and they should work together to obtain the best results. The engineer in many ways can assist the fireman, and every advantage should be taken by the crew in the feeding of coal, the building up of steam pressure or the feeding of water to the boiler. The coal should be fired two or three scoops at a time, and all factors in the operation of the locomotive should be as regular as possible.

* A paper read before the St. Louis Railway Club.

† Inspector of Boilers, Elevators and Smoke Abatement, City of St. Louis, Mo.

The best known and most efficient smoke-abating device on locomotives consists of steam jets at the fire-box, with an arch over the fire and a stack blower. The stack blower is used for increasing the draft when the engine is standing or moving slowly; the arch for maintaining a high furnace temperature. If the firing is light, often the steam jets will supply the necessary air for combustion and mix the gases from the fuel.

The problem of smoke prevention is the problem of perfect combustion, which is accomplished by three conditions, namely: The proper air supply, the proper temperature and the thorough mixing of the air and hydro-carbons or gases.

Under favorable conditions, with sufficient draft, good furnace construction, mechanical stokers and a fairly uniform load, it is possible to eliminate nearly all of the smoke from stationary plants. In locomotives nearly all of these conditions are lacking. The load is variable, draft is furnished by means of a blower or exhaust, the furnace construction is not conducive to perfect combustion, and the firing is done by hand.

A number of stokers have been tried for feeding coal mechanically into a locomotive fire-box, but apparently none of these devices have been successful enough to warrant their adoption.

It is evident, therefore, that if there is to be any appreciable reduction in the amount of smoke emitted from locomotive engines it must be accomplished by careful firing and close attention to the use of the stack blower and steam jets. To obtain the desired results it is necessary to issue positive instructions to the engine crews and to maintain constant supervison to see that such instructions are carried out.

Some roads have employed expert firemen, who ride with and instruct the engine crews in the manipulation of the fires and the firing of the coal. Others employ fuel experts for the same purpose. This indicates that some of the roads recognize the necessity of instruction and supervision.

While much has been said as to the careful firing of coal, the writer realizes that the engine crews should be supplied with the best means, such as fuel, etc., that the roads can supply.

The quality of the fuel has a marked effect in maintaining the fires. The fuel should not be too fine, but should be as clean as possible, the lumps should be broken up to fist size, and not fed into the furnace as they come from the tender. The writer has seen lumps of coal fired that were as large as one's head, and in some engine tenders has not found a lump of coal as large as a fair-sized apple. In one case only has a uniform size of coal been observed; in that case the coal was known as the egg size.

There seems to have been little or no attention paid to the quality of coal supplied to the locomotives, and a little closer attention to this will amply repay for the trouble and extra expense incurred. The coal used on 90 percent of the locomotives does not begin to compare with that of the average stationary plant. A case was recently related to the writer of one energetic fireman who, realizing what was expected of him on entering and departing from the city, had picked a carefully selected quantity of coal from the tender, which he used in making his entrance and exit from the city. This is an extreme case, but it well illustrates the point.

There is another class of railroad smoke which is very seldom mentioned, yet is disagreeable and almost a constant offender, namely, the round-houses. The usual round-house is a low building, with short smokestacks to carry off the smoke and waste gases. Smoke, dirt and soot are everywhere present, and at best is a disagreeable place to work in, as well as being an annoyance to anyone residing in the vicinity.

The construction of round-houses has been the same for years. We have some in St. Louis that need reconstruction very badly, and I know of no good reason why apparatus for producing mechanical draft, connecting all smokestacks and discharging through a washing chamber into one large, high stack, similar to boilers served by one stack as in our industrial plants, should not be installed in all round-houses.

By the installation of an exhaust fan the draft would be better, enabling the fires to be prepared quicker; the smoke and soot, passing through sprays and sheets of water in the washing chamber, would be held in suspension, allowing the gases of combustion to escape into the atmosphere possessing a light gray appearance. The installation could be made without the smoke-washing arrangement; the smoke, however, would be more dense as it escapes from the stack. Both plans have been tried in Chicago recently and have proven satisfactory, and I recommend the consideration of both plans to the designers of round-houses and members of the St. Louis Railway Club as a feasible plan to eliminate the disagreeable smoke and soot from this class of offenders.

Believing that the members of the St. Louis Railway Club would be interested in the work of the city smoke inspection department relative to steam railroads, I have prepared tables which give data of locomotive equipment of the various roads, together with the department's work of inspection made since Jan. 2, 1912.

RECORD OF LOCOMOTIVES.

Name of Road.	No. of Locomotives in Service.	No. of Devices Installed.	Percent of Devices Installed.
C. & A. and T., St. L. & W.	12	2	16⅔
Mo. Pac. and St. L., I. M. & S.	134	35	26
St. L. S. W.	4	0	0
Terminal Railroad Association	131	44	33
Wabash	43	27	63
Frisco and C. & E. I.	49	24	49
C., P. & St. L.	1	0	0
M., K. & T.	8	0	0
C., C., C. & St. L. and N. Y. C.	8	7	87
C., B. & Q.	22	22	100
B. & O. S. W.	8	7	87
Illinois Central	6	6	100
Manufacturers' Ry.	5	0	0
Rock Island	17	0	0
Vandalia-Penn.	6	0	0
M. R. & B. T. R.R.	1	0	0
American Car & Foundry Co.	4	0	0
Total	459	174	38

Table No. 2 is a record of observations and percent of violations for January and April, 1912. The record of six roads is given in the order of the number of locomotives operated. Observations were made on passenger, switch and freight engines.

The table gives the comparison between the percent of devices installed and the percent of violations. It will be noted that as the inspection continued the percent of violations decreased, showing the effect of inspection and the reporting of violations. The observations of February and March are purposely omitted, there being a small number of observations made in both months, whereas in the months of January and April approximately the same number of observations were made.

TABLE No. 2.

Railroad.	Locomotives.	Percent of Devices Installed.	January.		April.	
			Observations.	Percent violations.	Observations.	Percent Violations.
Mo. Pac. and St. L., I. M. & S.	134	26	233	38.2	115	33.0
Terminal R.R. Association	131	33	518	57.5	549	32.0
Frisco and C. & E. I.	49	49	100	32.0	113	23.9
Wabash	43	63	125	29.6	139	21.6
C., B. & Q.	22	100	53	13.2	91	6.6
Rock Island	17	0	11	9.0	8	37.5

Table No. 3 is a record of observations and percent of violations for January and April, 1912. The observations were made of roads operating passenger engines only.

Comparison clearly shows the relation between the percent of devices installed as well as the reduction in percent of violations as inspection continued.

TABLE No. 3.

Road.	Passenger Engines.	Percent of Devices Installed.	January.		April.	
			Observations.	Percent Violations.	Observations.	Percent Violations.
C. & A. and T., St. L. & W.	12	16.6	40	37.5	60	18.4
M., K. & T.	8	0.	25	36.	28	17.9
C., C., C. & St. L. and N. Y. C.	8	87.	41	22.	56	10.7
B. & O. S. W.	8	87.	6	33.	7	28.6
Vandalia-Penn.	6	0.	26	42.3	50	24.
Illinois Central.	6	100.	18	50.	27	14.8

TABLE No. 4.

Road.	January, 1912.					
	Observations.			Percent Violations.		
	Passenger.	Switching.	Freight.	Passenger.	Switching.	Freight.
Mo. Pac. and St. L., I. M. & S.	60	128	45	38.4	41.5	33.4
Terminal R.R. Ass'n.	....	518	....	....	57.5	....
Frisco and C. & E. I.	68	19	13	23.6	58.	38.4
Wabash	57	57	11	30.	33.4	9.
C., B. & Q.	46	4	3	10.9	50.	....
Rock Island	6	5	....	....	20.	....
	April, 1912.					
Mo. Pac. and St. L., I. M. & S.	61	50	4	28.	36.	100.
Terminal R.R. Ass'n.	....	549	....	....	32.	....
Frisco and C. & E. I.	79	5	29	19.	....	41.5
Wabash	76	53	10	10.5	30.1	60.
C., B. & Q.	79	12	....	6.3	8.3	....
Rock Island	5	3	....	40.	33.3	....

TABLE No. 5.

Road.	No. of Locomotives.		
	Passenger.	Switch.	Freight.
Mo. Pac. and St. L., I. M. & S.	44	35	55
Terminal Railroad Association	....	131	....
Frisco and C. & E. I.	19	10	20
Wabash	15	18	10
C., B. & Q.	9	6	7
Rock Island	6	1	10
	No. of Devices Installed.		
Mo. Pac. and St. L., I. M. & S.	....	35	....
Terminal Railroad Association	....	44	....
Frisco and C. & E. I.	4	10	10
Wabash	15	8	4
C., B. & Q.	9	6	7
Rock Island	....	....	....
	Percent of Total Equipped.		
Mo. Pac. and St. L., I. M. & S.	....	100	....
Terminal Railroad Association	....	33	....
Frisco and C. & E. I.	21	100	50
Wabash	100	44	40
C., B. & Q.	100	100	100
Rock Island	....	....	....

Table No. 4 is a record of observations and percent of violations for January and February, 1912, by the roads, tabulated same as Table No. 2. Observations and percent of violations are given for passenger, switch and freight engines. The consistent reduction in percent of violations will also be noted.

Table No. 5 gives the detail of locomotive equipment of roads tabulated in Table No. 4.

Black Sheet Tanks

Galvanized tanks, rectangular or cylindrical, but more usually the former, are the ordinary article of commerce; so much so that the light gage tank made of black sheet is in many tank shops almost unknown.

For some purposes, however, open top and closed tanks of about one-eighth-inch plate and of black finish are necessary. Anywhere that tanks are to be used for chemical purposes it is as well to make quite sure when booking the order that the presence of zinc galvanizing is permissible. Water-softening plants or apparatus using chemical reagents, consisting of measuring tanks and sediment and scaling trays contained in a larger tank, must necessarily be made black. The presence of zinc in this instance gives an undesirable reaction with the chemicals employed and vitiates the results for which the plant is made.

It is usual for such black tanks to be coated with a preparation of tar termed Dr. Angus Smith's Composition, the formula for which is quite well known. Such protective is applied hot, the usual method being to dip the completed articles bodily into a quantity of the hot liquid. Cast iron water pipes are always so treated.

In many instances, however, any coating whatever is prohibited, from the reasons given above.

It may be news to some that concentrated sulphuric acid may safely be stored in black sheet tanks. Indeed, quite a trade is springing up for drums of extremely thin gage (20 S. W. G.) for the transport of this extremely corrosive fluid. If diluted to twice its bulk with water it instantaneously attacks W. I. or M. S. sheet and perforates it in a very short while. In its strong concentrated form, without the addition of water, it cannot chemically react upon iron or steel. Needless to say, it devours zinc, so that galvanizing is out of the question, as such coating would impair the chemical purity of the acid.

It is a proverb in the galvanizing trade that "anything is good enough to galvanize"; so much so that there is a general belief, founded upon experience, that galvanizing impairs the strength of iron or steel. Exhaustive tests made years ago in the matter of crane chain disposed of this contention. The fact really is that inferior material is considered good enough to galvanize. The belief is correct, but its current reason inaccurate.

This same belief affects workmanship. Imperfectly closed seams are tight enough after a visit to the galvanizer.

In the case of black tanks when these are definitely called for, the maker of galvanized tanks finds his usual workmanship ineffective. Single riveted seams in one-eighth-inch plate do not suffer heavy calking, so that the plates must be flat at the joints and the seam holes be fair. Calking must be lightly done or the plate buckles at the seam, making the last state of the seam worse than the first. Tank makers rarely calk the inside edge of plates, but for black tank work this is imperative. Some black tanks have come under the writer's notice which would fail to hold small coal, let alone water. Usual methods, then, are so far unsatisfactory.

Shipyard experience of light bulkhead work provides a remedy. When plates have to be put together where calking is either not possible at all or possible only on one edge of the seam, the plates are put together with strips of sail canvas steeped in boiled oil and red lead. These strips are prepared the width of overlap of plate, and after steeping dried out hard. The hot rivet burns a hole through the canvas joint, while the conduction of the plate around the holes prevents the charring of the portion between plates to any serious extent. Such riveted seams are a first-rate watertight job.

Black tanks put together in a similar manner are absolutely watertight and suitable for any purpose where galvanizing is ruled out. There is no need, then, to trust to the rusting up of joints, always a poor and lame apology for a weeping seam. Two tank firms have expressed themselves indebted to the writer for the suggestion, and for some time have been making their occasional black tanks in this manner with satisfactory results. A. L. HAAS.

Boiler Shop Geometry—Almost

BY JAMES F. HOBART, M. E.

"Hello, Mr. Hobart! Have you brought along that geometry stunt which you promised me the other day?"

"Sure, John! I've got a whole bag full of them! What particular kind would you like this time? What bit of work is worrying you the most just now? And say, John, any time you would like to have something special about any job you are up against, then just write your question to the editor of THE BOILER MAKER. Send it to him and he will pass it right along so I can come over quick and talk it over with you. Don't be bashful, John, just send along your questions, and tell Tom and Bill to send along as many of their own as they want to."

"I'll be mighty glad to do that, Mr. Hobart, and I know the other boys will like to do so, too. But to-day I'm kind of up against it with two sheets that are to make an inside and an outside course after they are riveted together. I get the holes laid out all right, but they don't always come fair. And sometimes I get the lap too loose or too tight. If geometry can help any with these things, I'm going to be 'from Missouri!"

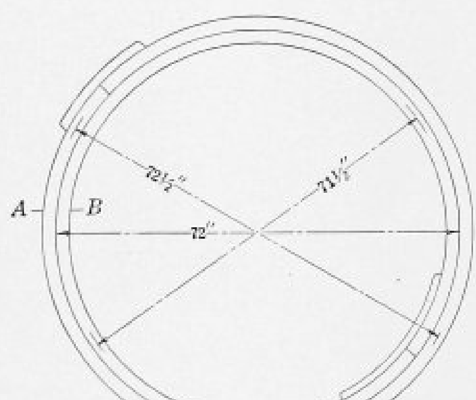


FIG. 1.—INSIDE AND OUTSIDE COURSES

"Then I'll 'show you,' John, and you can see how much geometry is on the job—there! Now, let's see the sheets. Oh! here they are. Just two plain pieces of ½-inch plate for inside and outside courses of a 72-inch shell? Why, John, you couldn't have a simpler layout if you looked the shop over from top to bottom. What's the trouble?"

"I know that, Mr. Hobart. I 'spose the job is so darned simple that I can't see the right way to do it, but that don't bring the holes right. You see, it's like this" (sketches Fig. 1 on a plate), "one course, *A*, must be 72 inches in diameter inside, the other course, *B*, 72 inches in diameter outside. When I lay off the inner course sheet three and one-seventh times 72, and add three times the plate thickness, which amounts to 1½ inches, I get the length of course to be 18 feet 10 2/7 inches plus 1½ inches, or 18 feet 11 25/32 inches long. Now, how much must be added to get the length for the other sheet, or will this one be the outside course and how is the inside course figured?"

"I savey, John! You are up against the amount of metal taken up by a plate when it is bent to a circle. The foreman told you to always allow three times the thickness for 'take-up,' but that don't tell you where the metal goes to, or how much you must allow additional in the outside course to just fit over the inside course. Is that 'What's what?' "

"That's dead right, Mr. Hobart. I'm all ready to 'be shown' in this, but I don't know where I get off at in the circle business."

"Say, John, just slip a tape around that course which you laid out 18 feet 11 25/32 inches. It has been rolled up, hasn't it?"

"Yep! Rolled up and a couple of bolts put in to hold the circle. Here's the tape. I'll run around with the end and you do the measuring. What's that? The course measures 18 feet 11 49/64 inches! Why, that is only 1/64 inch less than the length of sheet as laid out. Pretty close, isn't it?"

"Yes, John, close enough to your layout, but just look in this table of diameters and circumferences, and you will find this number, 227.765, which is the decimal inches of 18 feet 11 49/64 inches, and the table shows that this is the circumference of a circle 72½ inches in diameter outside, or 71½ inches inside diameter for ½-inch sheets! And this means that your course is too large for an inside course and too small for an outside one!"

"Oh, hang it all, Mr. Hobart, what am I up against, anyway?"

"You are up against 'rule of thumb' calculations, John. That's all. You need a little geometry to straighten things out and then it will be as easy as sticking a red-hot drift-pin into a snow bank. To begin with, that '3 1/7' business is a delusion and a snare, only good enough for rough work. With that ratio you get the length of sheet as 226 2/7 inches, which is the same as 226.2875 in decimals. Look in the reference book, and the circumference of a 72-inch circle is given as 226.195 inches, against 226.2857 inches. The difference is .09 inch, or about 3/32 inch, so our 3 1/7 business gives a circle a little too large. If we wish to be real particular and close, we must use the quantity called 'Pi (π)', which is the ratio between the diameter and the circumference of a circle. This is commonly taken as 3.1416. If we divide 1/7 into a decimal fraction we get .1428, which, with 3 before it, is a little too large. The circumferences in the tables are calculated with 'Pi' carried out to eleven decimal places, like this: Pi = 3.14159265359. This is what geometry gives as the multiplier between diameter and circumference when you wish to be real close and exact. For ordinary work 3.1416 is close enough, and much more dependable than the old rule-of-thumb 3 1/7."

"Say, Mr. Hobart, how do they get that number 'Pi', anyway? What does it come from?"

"We'll talk about that bye and bye, John. When we come to the rivet spacing, then we will look after 'Pi'! Just now, I'll only say that geometry will show where it came from and we'll catch up with it in a little while."

"All right, me for the wait-box, and I'll be right out in front when you tell about 'Pi' and its beginning!"

"Good! Now, let's have that diameter business straightened out. First thing, we will see where that three thicknesses of metal, 1½ inches, goes to. If you roll up a plate as shown at *I*, Fig. 2, it will be found that the side *C* has become shorter, while side *D* is longer than before. There is a place in about the middle of the thickness, marked *N*, which stays the same length as before and does not lengthen or shorten during bending. This, John, they call the 'neutral axis,' for the reason that it don't do anything one way or the other. Now, then, if we can do the measuring on this 'neutral' line, or axis, we can keep our measurements after the sheet is rolled up."

"But how is a fellow going to make measurements in the middle of a sheet?"

"That's dead easy, John! Just take away half the thickness of sheet from the diameter of the course on each side. That's

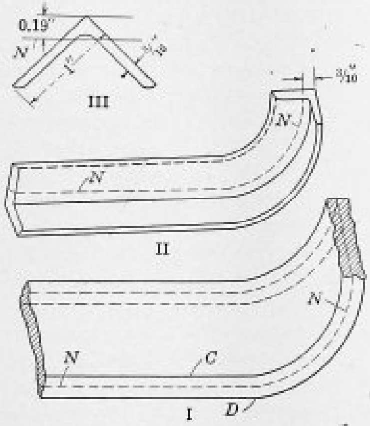


FIG. 2.—BENDING STOCK

a whole thickness of sheet taken from the diameter, isn't it?"

"Sure thing; 72 inches with ¼ inch taken off each side, leaves 71½ inches for the diameter of the course after it is rolled on the line *N*, Fig. 2."

"That's the stuff, John. You are 'showing' all right. Now, let's look in the reference book table of diameters and circumferences of circles, the lengths of circumferences for 71½ inches and 72 inches. The last we have found to be 226.195 inches. The 71½ inches diameter shows a circumference of 224.624 inches, or 1.54 inches less than the diameter of the 72-inch circle. And, John, do you see how close this difference is to the 1½ inches—three thicknesses of plate, which you added to 3 1/7 times the diameter of boiler? Now, then, this is just where the 'three times the thicknesses of plate' comes in. The boiler maker doesn't stop to add 3 1/7 times the plate thickness, but just let it go at three times. And there is a good reason for this. The 3 1/7 business gives a circumference a bit too large as far as it goes, while three times the thickness of plate gives not quite enough, but the two, both wrong, offset each other, and the circumference comes out correctly within 1/64 of an inch, as we found elsewhere. Now, John, they say that 'two wrongs never make a right,' but it seems to come mighty close to it in this case, and that is why the boiler maker can use the 3 1/7 business and still come out close enough for some ordinary work."

"Say, Mr. Hobart, do sheets always bend up as shown by Fig. 2, one side stretching while the other side of the metal upsets?"

"Sure thing, John. That's the way of it every time. But in order to follow this rule, the metal must be as soft one side as it is the other, and there must be as much resisting metal on one side of the line as on the other side. Take the case of bending an angle, as shown at Sketch II, Fig. 2. The geometry chap has figured out that the metal in the flange, at a distance from the web which is close to, balances along a line just 3/10 inch from the outside of the other or web leg of the angle. But this only holds good from a 1 inch by 1 inch angle, 3/16 inch thick. If the legs of the angle are only ⅛ inch, then the neutral axis will be closer to the face of the angle, and its distance, or 'radius of gyration,' will be .31 inch instead of .3 inch. But if the legs of the 1 inch by 1 inch angle are ¼ inch thick, then the distance will be only .29 inch from the face of the angle."

"So that's the way they figure where angles will bend, is it? I never could see how they did that trick."

"Yes, John; that's the way it is done. They bunch all the metal in the angle or other shape into a point and call the bunch the 'moment of inertia' of that angle. They call it that name for want of a better one. That's the only reason for the name, and the distance of the bunch point, from some face of the shape, is called the 'radius of gyration,' which is, as stated, .3 inch in the 1 inch by 1 inch by 3/16 inch angle; but if you roll the angle up until it rests upon both legs, instead of flat upon one, then the bending point (neutral axis) will be in a line passing through the angle at *N*, Sketch III, Fig. 2, just .19 inch from the corner of the angle. So you see, John, that while the line of bending passed through the center of a plate or rectangle, it varies in other shapes, according to their make-up. You will find all these distances listed in the Mechanic's Reference Book, and you must get after these things and study them out before you can design work and before you can lay it out in the best possible manner. Some men lay out work well, without any knowledge of these things, but they could do better work if they did know about the scientific part of their work, and they would surely get better pay if they knew and could use the little geometrical stunts of the business."

"That for me, Mr. Hobart, just as fast as I can study it all out. Gee! but there's a whole lot for a fellow to learn, isn't there?"

"Yes, John, there is a whole lot, but remember that you never have to learn but just one thing at a time. That's the way you climb a ladder, one rung at a time. You can't take the top rungs first unless you are going down instead of up, and just remember also that the rung from next to the top to the top is no harder than the step from the bottom rung to the one next to the bottom. That is as true as taxes, but many don't seem to realize it, or they would climb up a whole lot easier.

"Now, John, about those inner and outer courses. From what we have found out, it seems that you must either calculate the length of sheet from points midway the thickness of the course at either side of the boiler, taking the diameter as 71½ inches for inner course *B*, Fig. 1, and 72½ inches for outer course *A*. Multiply each of these diameters by 'Pi' = 3.1416, or else multiply 72 by 'Pi' or by 3 1/7, then add three thicknesses of sheet for the length of the outside course and subtract three plate thicknesses for the length of the inside course. Therefore, the sheet you laid out 18 feet 11 25/32 inches is all right for the outside course, and if you subtract six plate thicknesses, 3 inches, the remainder will be the length of the inner course, which is 18 feet 8 25/32 inches. Therefore, the first layout is right for the outer course, and you only have to get out a sheet 3 inches shorter for the inside course!"

"Then how are the rivet holes spaced? One sheet is 3 inches longer than the other, but there must be the same number of holes in each, of course. Now, how are these holes to be laid out so as to come fair with each other?"

"The holes are to be laid out, John, just exactly as you laid out the sheet on page 292 of the October BOILER MAKER. That is all there is to it. Nothing hard about that, is there, John?"

"N-n-no. But I kinder got all mixed up trying to space the holes in one course to fit those in the other course. And I couldn't make the spacing come out right!"

"So! You fell down on the spacing, did you? Let's see what the trouble is! Take the inside course. It is to be double lap riveted, you say, along the girth seams, and those are what we are after? With 1-inch rivets in 1 1/16 holes, spaced as nearly as possible to 3.32 inches, there will be either 67 or 68 rivets in the seam. That would make the holes (using 68 rivets) 3.305 inches pitch, and with 67 holes they would be 3.35 inches apart. To tell which should be used, it will be necessary to calculate the plate strength after the holes have been reamed, then calculate the strength of the rivet section with both 67 and 68 rivets; then take the one, either 67 or 68, in which the percentages of plate and rivet strengths are the nearest equal. That's the way to work out the number of rivets, when you want to get a seam right down to the last percent of efficiency."

"Say, but there's a whole lot of work in it, ain't there?"

"Sure, there is. There's work in anything worth having, and the whole engineering business is nothing but constant looking out for a whole lot of little details, the lack of each

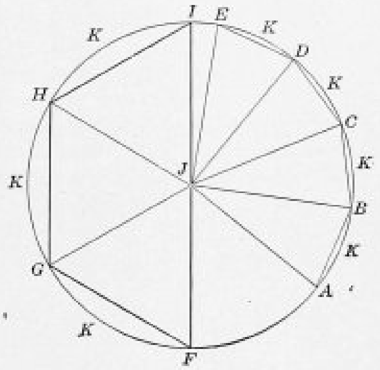


FIG. 3.—CHORDS AND ARCS

one lessening result values a trifle—sometimes a whole lot. So see to it, John, that you look after the details, the little things, and let the big ones go. They are the most able to take care of themselves until you are able to have assistants to look after the details for you, while you put in all your time working the big stunts. So see to it, John, that you have the 'know-how' of the details right down fine before you try to bite off big mouthfuls of engineering food. If you don't savey the details, you will bite off more than you can chew—every time!"

"But tell me, before you go home, how it is that with the compasses set to 3.3 inches for 68 rivets, that the spacing won't fit the punch holes after the sheet is rolled up?"

"Sure they won't. Just look at Fig. 3 and you will see the reason. And right here is where a whole lot of geometry is at home all the time. When we step along a sheet with the dividers, we are working along the surface *A, K, B; B, K, C; C, K, D*, etc., but when we space around a rolled-up sheet, then we go direct, *A, B; B, C; C, D*, etc., and the spacing overruns the punch marks in the rolled-up sheet."

"So that's the way of it? Why, I tried for a long time to make the same spacing fit a course after the sheet was rolled up, and even kept the dividers set with the very same distance the sheet was laid out with, but it was 'no go!' I see where the trouble is, and you may be sure I won't get caught again that way. The distance around the circle, *A, K, B*, is greater than the short cut *A, B?*"

"Sure, John; that's exactly what the reason is. And right here are a couple of mighty interesting geometry stunts, and valuable ones, too. I told you I would tell later how they found 'Pi' and where that pastry sounding thing comes from. And here we have it, right in Fig. 3. If we take the diameter of the circle, distance *F-I*, in the dividers, and attempt to space around the circle with that distance, we can get just two steps, one from *F* to *I*, the other from *I* to *F*, before we get back to the starting point *F* again. But if we take half the diameter, from *F* to *J*, in the dividers, then we can space around in just six steps—*F-G, G-H, H-I*, etc. With this way of stepping around a circle, on chords, the circumference is just three times the diameter. With the larger chord, equal to the diameter, we found the chordal distance to be twice the diameter. This shows that the shorter the spacing steps the greater the distance around the circle. So, if we take some very short chords, so short that we can't find any difference between the chords and the arcs, then we will get a circumference of about 3 1/7 times the diameter, and here is where the 3 1/7 comes from."

"I always wondered how they got at that number; whether they slipped a tape line around a circle and then divided the circumference by the diameter."

"That is a pretty good way, too, John, and you will remember we tried it with the course you had bolted out, only we didn't divide by the diameter. Now, this chord and arc business. You may have guessed that the short cuts *A* to *B*, *B* to *C*, etc., are called 'chords,' while the distance around the curved pieces *A-K-B, B-K-C*, etc., are called 'arcs.'"

"But, Mr. Hobart, how do they measure close enough, in finding the circumference? I should think there would be a limit to such measurements, and the limits might not be close enough. How do they do the stunt?"

"There is a limit, John, to actual measuring, and, as you say, it don't take long to get down to it. But there is another method which is always used in close calculations of this kind, for when the wise men can't divide a thing close enough with the dividers, then they use imagination, and that works pretty fine. Why, John, you can imagine the circumference of that outside course divided into little lengths so very short that they can't be divided again, can't you?"

"Sure, that is no trick at all, but how can the imagined distances be measured? That's what gets me!"

"They measure them, John, with imagination, just as they do the dividing. There is a high branch of mathematics called the calculus, which deals with these imagined distances, and also sums them up into actual figures, so that is the way they figure out that the distance around a boiler is 'Pi' times its diameter. And when you see in some of the technical journals scare-head algebra layouts something like this, $\int$, then it is understood that something is being integrated—taken to pieces in little slices which cannot be thinner, and afterwards put together again and measured up to give the required answer to 'problems' which can't very well be worked out by other methods."

"Gee! But I thould think that stunt would be a whole lot interesting. Is it as interesting as those geometry things?"

"You better believe it is, John, and it helps a fellow work out a lot of geometry matters that common arithmetic won't hardly touch— What do you call it? Oh! it is called the 'calculus,' and it's what all the high-pressure mathematical sharps use for calculating the movements of the stars, sun, earth and such things."

"Say, Mr. Hobart, don't tell me any more things I don't know—not to-day, anyway. I had a rivet keg full of them when you came in, but bet I could fill a barrel with them now. Guess I had better write a book about 'things I don't know.'"

"The very best way to learn those things, John, is to talk and write about them, and just as soon as you find out you don't know a thing, then and there you begin to learn things about it."

"Then I'm in the graduating class, all right, for I've found out a few. Suppose you'll be over again soon with more geometry stunts?"

"Sure, John; I'll be over as long as you are interested, but don't forget the questions you and Bill are to send in to the editor."

Upkeep of Marine Boilers

BY CHARLES S. LINCH

It is true in many cases that no part of marine machinery receives more abuse than the steam generator. In placing a contract the owner will try to get as cheap a job as possible, never considering that during the remainder of the plant's life he will spend large sums for fuel, and perhaps for large repair bills. Go on board many ships and take a look at the boilers. In numerous cases we see a state of affairs that is absolutely startling. What is there to keep oil and grease out of the boilers? At what temperature does the feed-water enter the boiler? The writer some few years ago examined a boiler of a coastwise ship. This boiler was of the leg type, and had he been told that it was coated with grease he would not have believed it. As a matter of fact, however, the boiler was worse than coated. The stays were covered with a nice, thick coating of grease, which was well baked on. On the back connection, on the crown sheets—in fact, on every place one could see—there were signs of oil, and he wondered that it ever kept together and that there never was a loss of life and floating property.

Some time ago a large ocean-going tug was fitted with a new boiler. At the time the boiler was being built repairs were also made to the machinery, and in the latter was the reboring of the high-pressure cylinder. This tug was fitted with a heater and grease extractor. After the tug was in commission complaints were made regarding the coal consumption. An investigation showed that the grease extractor was not used. The heater coils were covered with grease, and the boiler was thoroughly saturated with grease and oil. Upon seeking a reason I found that the engineer had no time to renew the cartridge and he had been using great quantities of oil in his high-pressure cylinder.

Now, there are ships running that have no grease extractor, and many are without heaters, distillers or evaporators. The reason for this is simply the question of first cost. Yet many times the price of these outfits is paid for in the saving on coal bills, and that in a comparatively short time. What is the cost of a grease extractor compared to the cost of a furnace, plus the loss occasioned by a tie-up? It is not my purpose to talk feed heaters, grease extractors or other specialties. I am, however, at a loss to understand how owners can ignore this vital part of a ship's plant. Aside from the enormous loss of efficiency as a steam generator caused by grease and oil by the introduction of feed at a low temperature, enormous strains are put up in the structure, and often cause trouble, which likewise is very costly. We know that distilled water is not good for a boiler, and to avoid any trouble we simply use enough salt feed to give the boiler a fine coating of salt. It is a very poor plan, indeed, to use oil in the cylinder of a new engine, and it should be worked without it. There will, however, be a very slight amount of oil introduced into the cylinders, especially in the low-pressure cylinder, from the swabbing of rods.

There is not to-day a grease extractor that will take all the oil out of feed-water. Oil can only be entirely eliminated by taking it out of the steam. If we had a grease or oil extractor placed in the eduction pipe we could practically eliminate all the oil. Take, for example, a piece of plate, say No. 16 B. W. G., and form it so that it will hold a small quantity of water. Before introducing the water smear a portion of the surface of plate with a small quantity of oil; then introduce the water, place the plate over a candle, and note what takes place. It is a very interesting sight, and one would be surprised to see what happens. Further, we can readily understand why crown sheets come down.

A well-made boiler is a dependable thing, and when properly proportioned and designed, as well as properly handled in service, is capable of showing very high efficiency. It matters not, however, how well designed or built if its treatment in service is bad. A man will pay thousands of dollars for a race horse, and he sees to it that his animal is treated with the greatest care and that everything conducive to its longevity is obtained. Why? Because it is a source of revenue. Yet a boiler, costing more, and being even a greater source of revenue, is permitted to be handled by ignorant attendants, and anything conducive to increased efficiency is considered too costly to install. Think of the boilers to-day on so-called modern ships, let alone in stationary plants, which are treated to a good surface blow every day to get rid of the oil and scum carried over from the use of oil in the engine! Is this heat worth saving? Does it not represent money? Does it not represent energy going to waste? Does it not denote terrific strains on the boiler itself? Does it not show lack of appreciation of cause and effect? The answer may be that we have not enough auxiliaries to heat the feed. Yes, that may be true enough, and theoretically there is no gain by heating feed-water with steam direct from the boiler, and a little thought will make the reason clear; but there is a gain, a vast gain, in the life of boiler, because the strains are eliminated. If the strains put up were constant and not intermittent in character, they would not be so dangerous; but is it fair to suppose that intermittent stresses are set up and no injurious effects follow? I do not think so. These are abuses that can be remedied, and should be, aside from the question of fuel economy. It requires the closest contact between the gases and the walls of the boiler and between the wall and the water for efficient transmission of heat from the gases of combustion to the water. If this condition must obtain, then we will have to keep all foreign matter out of our boilers. We all know that the most efficient heating surface is that of the furnace crowns and combustion chambers, this being, of course, due to the difference of temperature between the two sides of the plate. Then there is freedom of the surfaces from deposits of soot or ash, and if proper precaution is taken freedom from mineral or earthy matter.

Now, as for the remaining parts adding to heating surface, we can eliminate them in the present article, as the above-mentioned surfaces are those affected by grease and oil. If I could picture the condition of some boilers which I have examined internally, I am sure it would hardly be credited. Yet the fact remains that such conditions did obtain and still obtain, and many boilers are filthy and the line of oil marks are clearly shown. At one time in the history of the steam engine, I will grant, cylinder lubrication was a necessity, and the old grease cup on the top of cylinder heads was considered a thing of beauty and a joy forever for the engineer. In the present-day conditions it is not necessary. If kerosene (paraffin) is at times introduced into the boiler it not only insures a harmless lubricant but at the same time a most efficient one, as the cylinders and the surface of cylinder walls soon take on a magnificent polish, and, again, there is a chemical action which hardens the surface, and in a period of time the walls reflect like a mirror.

What is the gain by using a feed-water heater? Let us first suppose that the water is fed to the boiler at a temperature of 110 degrees, and, further, that the working pressure is 180 pounds gage or 195 pounds absolute. We will assume that 8 pounds of water are evaporated under these conditions per pound of coal. The total heat of steam at a pressure of 195 pounds absolute is 1197.5 British thermal units per pound. The temperature of the feed-water being 110 degrees we have 1197.5 — (110 — 32) equals 1119.5 British thermal units added to each pound of water passing through the boiler. Now, as 8 pounds of water are evaporated per pound of coal, we have 8 × 1119.5 equals 8956.0 British thermal units. Now suppose a heater is installed and our feed-water is to be raised to 212 degrees. To generate steam of 195 pounds absolute pressure from a feed of 212 degrees requires 1013 British thermal units, which is made up of the latent heat (845 British thermal units) plus 168 British thermal units, the sensible heat (168 British thermal units). We therefore have 8956 British thermal units, divided by 1013 British thermal units equals 8.84 pounds, or a gain of 10.5 percent. It is the practice, however, to heat the feed to 215 degrees and 220 degrees F., resulting in a gain of about 10.5 to 11 percent. It is unnecessary to carry this further.

Is it worth saving? Is the life of the boiler worth prolonging? Is the boiler to be credited with low efficiency because it receives but scant consideration? Is the engine to receive every consideration, while the steam generating plant is passed over with only sufficient interest to warrant the production of sufficient steam to enable the engine to turn the wheels and thus propel the floating body?

We are in latitudes where the coal pile is getting to be of some consequence, and where the boilers have to receive some scientific consideration. There is plenty of room for improvement in design, and there must be a more scientific method of handling when under way. There is no excuse for having dirty boilers, nor is there any excuse for having crown-sheet trouble caused by grease. It would take more space than can be given in this article to compare the cost of prevention and the cost of new furnaces. It would, however, be an interesting comparison.

I cannot close this without mentioning a case that came under my notice about three years ago. I was requested to go South and at a certain point meet a large ocean-going tug, bring her to Baltimore, and there make a complete examination and report, as on my report the boat would either be accepted or rejected. After the boilers had cooled down I went through them, and never inspected more finely-kept boilers; there was not a trace of grease in any part, the waterline was a well defined line, and I could take my fingers and erase all sign of it. It was properly coated with salt, just enough to prevent any injurious action of the water. The steam space was perfect, and one could have gone in those boilers without getting his clothes soiled, as the deposit of salt would brush off. There was no sign of pits; and, furthermore, no damp ash was allowed to accumulate around the front, and therefore no corrosion due to this cause was able to take place. The boilers, at that time, had been three years in actual, hard service. There was no indication of any part being strained; furthermore, there was not a sign of a leak of any kind. These boilers were built by the Harlan & Hollingsworth Corporation, Wilmington, Del., and were characteristic of their boiler work.

I have not since or do I ever expect to see finer treatment given boilers than these received, and the efficiency was very high. I had the pleasure of seeing a boiler plant a few days ago where the boilers receive first consideration, and here were boilers furnishing steam to a triple-expansion engine and the necessary auxiliaries; the feed temperature is held at 215 degrees F. The efficiency of this plant, taken from log entries, is very high, and I may say the thermal efficiency of the engines is likewise high; in fact, higher than that which ordinarily obtains. I can mention several ships of this line that show very high evaporative efficiency and where the boilers are the first consideration, and the superintending engineer, as long as I can remember, has been considered a crank on the boiler question, but results have amply justified his demands that the boilers receive certain proper treatment, and for the size of their ships they are the most economical and efficient.

We can design and construct, and on these points we can exercise judgment and produce a fine piece of work. In actual operation, however, we have no control, and it matters not how we design to satisfy all conditions of stress and strain; if the necessary precautions are not taken and the required preventatives adopted the boiler will not, and cannot, be efficient, and above all the attendants must be instructed and made to handle the boilers in a more scientific manner. Sludge, grease, excessive strains, and leaks caused by them, can be eliminated, dropped crowns can be likewise eliminated and money saved. It is up to the owner whether he wants dividends from every item of his plant or is satisfied to pay coal bills and tries to "grind" down builders in the cost of construction. The latter is the spigot, the former the bung-hole, and let us ease up a little on the poor spigot and get after this bung-hole, which is very much larger.

Construction of Ninety-Degree Elbow

BY C. B. LINSTROM

Fig. 1 shows a cross sectional elevation of the tapering pipe connection which is lap riveted and made up of seven heavy plate rings. The upper ring, *I*, is a section of a true cylinder and does not require a development for securing its pattern. The other sections are tapering, the connecting sections overlap each other, the difference in diameter, therefore, between the small and large ends of all sections, excepting ring *I*, is equal to two times the plate thickness. This is evident from the cross sectional drawing (Fig. 1). Section *I* could be made like section *I'*, but this would require some additional work in making the elbow. It is better to consider the ring *I* as a part of a horizontal pipe to which the elbow joins.

Proceed with the development of this problem by drawing a right angle triangle *A B C*. Upon line *A B* locate the center, *m*, of the elbow, and with *B m* as a radius draw the arc *m n*. Divide the arc *m n* into one less than the desired number of sections; therefore, in this case, divide it into six equal parts Then take one-half of one of these divisions and set off this distance from points *m* and *n* on the arc *m n* as at 1 and 1', thus determining the centers of two half sections. It is the usual practice to use half sections at the respective ends of a 90-degree elbow, because their use will produce a uniform or more symmetrical elbow.

Next divide the distance between 1 and 1' into the required number of divisions to produce five whole sections, as *II*, *III*, *IV*, *V* and *VI*. Through the points 1, 2, 3, 4, etc., on the arc *m n* draw radial lines connecting with point *B*, as *B D*, *B E*, *B F* and *B G*. The lines *D D'*, *E E'*, *F F'*, etc., taken on these radial lines, are the lines of intersection or miter lines between the joining sections; for instance, the line *D D'* is the miter line between sections *I* and *II*.

To arrange the different sections so that they will be symmetrical about the arc *m n*, simply divide the arc distances between points 1 and 2, 2 and 3, etc., into two equal parts and tangent to the points of division draw the respective center lines. About these lines and the miter lines the sectional views can be constructed

It is not necessary to draw in all of the sections shown in the drawing of Fig. 1, as enough information can be had from one section in order to lay off the necessary patterns. Consider ring *III* in this development. It is divided into two equal parts by line *O P*. Tangent to point *r* draw the center line *d' d'* about this line the sectional view of ring *III* is drawn. From points *d' d'* at the small and large ends lay off the required diameters, considering the thickness of plate. As mentioned previously, the difference in the two ends is equal to two times the plate thickness. Now with *d'* as a center, and with the neutral radius, draw a semi-circle for the small end; do the same for the large end. Divide these arcs into equal spaces. Then at right angles to the respective miter lines *E E'* and *F F'* draw lines from the points *a b c*, etc., until they intersect the miter lines, as shown. Connect the points a' a', b' b' and c' c', etc. These construction lines will be used in laying off the pattern.

Referring to Fig. 2, lay off the stretch-out line *m n*. Upon this line two stretch-outs must be laid off, one for the small end equal in length to the neutral circumference, the other equal to the neutral circumference of the large end. It is best to use the neutral dimensions in laying off the stretch-out, be-

Ordinarily the points d' e' f' g', etc., are used as centers for the rivet holes. To connect the sections together it will be necessary to scarf opposite ends of the pattern. For instance, the outer point d' on the small end must be scarfed in order that the connecting sections will set up snug. The inner point d' on the large end must also be scarfed; otherwise there will be a gap between the sections on account of the additional thickness of metal at the joints.

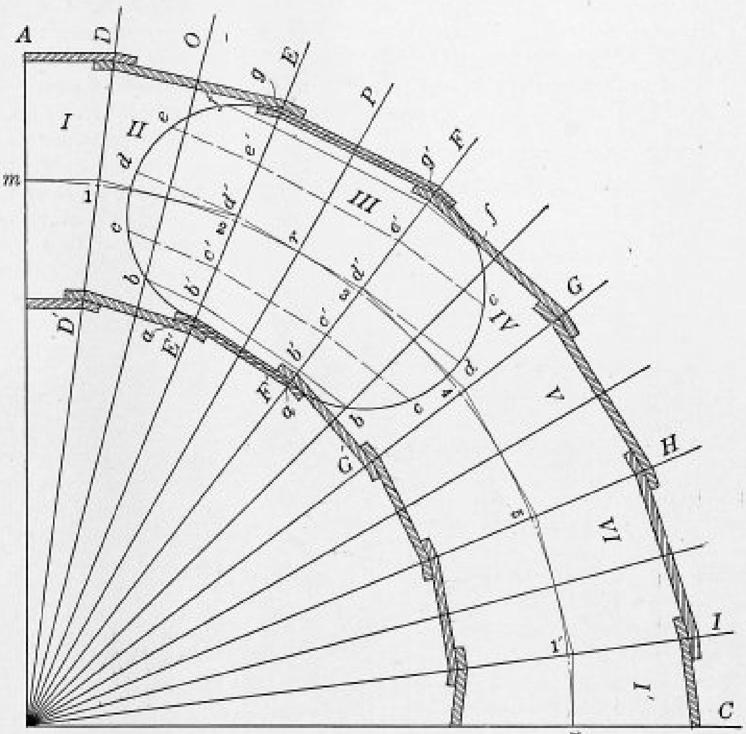


FIG. 1

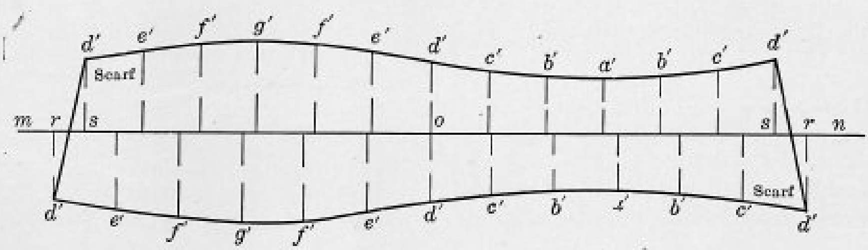


FIG. 2

cause at that point the plate neither gains nor loses in length during the operation of rolling. Divide the stretch-out between *r r* into two times the number of spaces contained in the semi-circle of the large end; divide the small end in a like manner. From the points on the stretch-out lines erect perpendiculars thereto. In laying off the pattern consideration of the location of the seam lines must be made. In light work it does not matter so much, but in heavy plate work no two seam lines should come together; they should alternate on opposite sides if possible. The seam should come on line d' d' for this section, and the seams for the adjoining sections should come diametrically opposite. Fig. 2 shows the development of the pattern as required to meet this condition.

The solution of this problem as given herewith is not mathematically correct, as, owing to the taper of the respective sections, the lines produced, as shown on the drawing—that is, the lines b' b', c' c', etc.—are foreshortened, owing to the difference between the diameters of the two ends. For practical purposes, however, the solution is sufficient. Allow for laps.

Ohio Boiler Inspection Law Nullified.—The Louisville & Nashville Railroad was awarded the decision, Oct. 18, in a case against the Public Utilities Commission of Ohio, in the United States District Court at Cincinnati, Ohio. Judges Warrington, Hollister and Knappen handed down an opinion that an act of the Ohio Legislature relating to the inspection of locomotive boilers on railroads in the State of Ohio was in conflict with an act of Congress on the same subject passed Aug. 11, 1910, and in contravention of the same. An order will be entered enjoining the Public Utilities Commission from interfering with the engines of the Louisville & Nashville in matters to which the decision relates.—*Railway and Engineering Review.*

The Chicago, Burlington & Quincy Railroad has placed an order with the Baldwin Locomotive Works for 25 Mikado (2-8-2) locomotives. This is in addition to the order for a like number reported last month, making a total of 50 recently ordered.

Transmission of Heat to Steam Boilers

For many years it has been the custom of mechanical engineers to compare the relative capacities of steam boilers by the number of square feet of heating surface which they contained, it always being assumed that one square foot of heating surface would absorb or transmit an amount of heat proportional to the difference in temperature between the furnace gases and that of the water in the boiler. This assumption is false, and the writer wishes to call attention to the fact that a number of square feet of heating surface in one type of boiler may or may not absorb as much heat as an equal

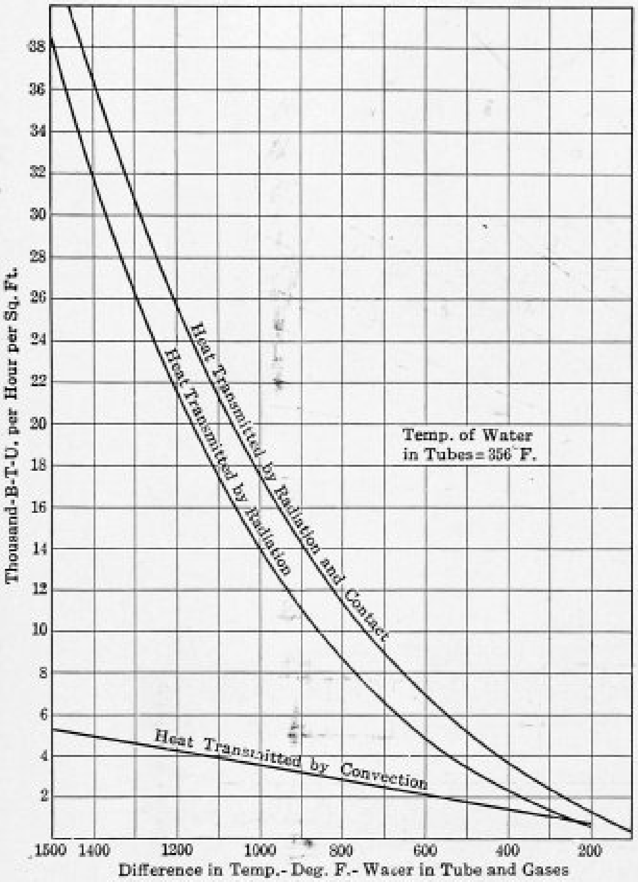


FIG. 1

number in another type of boiler, even though the furnace conditions, temperatures, etc., be identical.

In order to compare the relative steaming capacities of two boilers, consideration must be taken of the respective amounts of heating surfaces directly over the fire or furnace. A boiler having a large percentage of its heating surface so arranged as to receive heat by direct radiation from the fire and furnace walls will be capable of evaporating much more water per square foot of heating surface than another type of boiler having a smaller percentage of its surface located adjacent to the furnace. A boiler with a large percentage of its surface to receive heat by radiation from the fire will require less heating surface per pound of steam generated than a boiler with a smaller radiating surface.

Heat is transmitted to the heating surface of a boiler by two means:

1. By convection—i. e., contact of the hot gases with the heating surface.

2. By radiation of heat direct from the fire to the heating surface.

All gases are poor conductors of heat, but at high temperatures heat can travel through them very rapidly by radiation, in the same manner as heat travels from the sun through space to the earth. From the laws governing the heat transmission by radiation, and also from many experiments, it has been proven that for high temperatures such as are found in the boiler furnace the heat transmitted to the boiler by radiation from the fire and hot gases is several times greater than the heat transmitted by contact of the hot gases and heating surface. At lower temperatures the amount of heat transmitted by radiation is very small.

Hence to secure the highest efficiency of the heating surface, as much of it as possible should be placed in the path of the hottest gases or directly over the fire.

The heat transmitted to a square foot of heating surface is not proportional to the difference in temperature between the gas and the water in the boiler, but is proportional to that difference plus a function of the difference between the fourth powers of the absolute temperatures of the gas and the water in the boiler.

Let $H =$ the total heat in British thermal units transmitted to a square foot of heating surface per hour.

$H_c =$ British thermal units transmitted by convection per square foot of heating surface per hour.

$H_r =$ British thermal units transmitted by radiation from the furnace or gas per square foot of heating surface per hour.

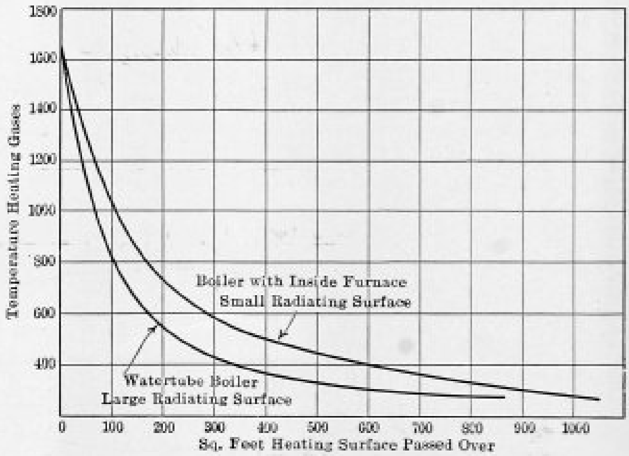


FIG. 2

Then $H = H_c + H_r$.

Let $t_1 =$ temperature F. of the hot gases passing over any square foot of heating surface.

$t_2 =$ temperature F. of the water in the boiler.

The formula giving the value of H_c—i. e., heat transmitted by convection—is very simple and much used by engineers for boiler work:

$$H_c = \text{about } 3\tfrac{1}{2}(t_1 - t_2)$$

The law governing the transmission of heat by radiation has been known to scientists for many years, nevertheless has been little used by engineers in the consideration of heat transmission to boilers. The number of British thermal units that can be transmitted to one square foot of surface per hour from an ideal black body of a higher temperature is

$$H_r = \frac{15.96}{100,000,000,000}(T_1^4 - T_2^4)$$

$$= .16\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right]$$

In these equations T_1 = absolute temperature of the hot gas furnace walls or fire, as the case may be = $t_1 + 460$ and T_2 = absolute temperature of the water in the boiler = $t_2 + 460$.

A large number of careful tests have been made on boilers, especially by German engineers, to determine what relation the theoretical law of radiation bears to what actually takes place in a boiler furnace. The formula below has been found to agree very closely to the results of numerous tests, and it will give a very close estimate of the amount of heat that can be transmitted by radiation from the fire furnace walls on hot gas to a square foot of heating surface directly exposed to the same.

$$H_r = .16\left[\left(\frac{.96T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right]$$

The temperature of the furnace brick work is usually about .80 percent of the temperature of the gas in the furnace.

By combining the formula for the transmission of heat by convection with that for radiation gives the total heat transmitted, which becomes:

$$H = H_c + H_r = 3\tfrac{1}{2}(t_1 - t_2) + .16\left[\left(\frac{.96T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right]$$

In a recent test of a locomotive boiler the firebox heating surface, which was 6 percent of the total heating surface in the boiler, evaporated 50 percent of the water. This gives an evaporation of 50 pounds of water per square foot of firebox heating surface. In stationary boilers about 10 square feet of heating surface is allowed per horsepower, which means an average evaporation of 3.4 pounds of water per square foot of heating surface. The reason for the high evaporation per unit of area in the locomotive firebox is the large amount of heating surface directly exposed to the high temperature of the fire. A very large amount of heat is radiated to the heating surface, according to the above law for radiation, which is proportional to the fourth power of the absolute temperatures.

The curves (Fig. 1) show graphically the amounts of heat that are transmitted per hour both for radiation and convection for various differences in temperature between the water and the hot gas or the fire. There is also a curve giving the sum of the two.

These curves show in clear and forcible manner the difference in heat-absorbing value between units of heating surface located in different parts of the boiler. For instance, a square foot located in that part of the boiler where there is a temperature difference of 1,500 between the hot gas and the water, will absorb by convection from the hot gases 5,250 British thermal units per hour and by radiation 38,200, or over seven times as much. The total heat absorbed being the sum of the two = 43,450 British thermal units, corresponding to an evaporation of about 45 pounds of water per hour.

The curve, Fig. 2, was taken from the German engineering magazine *Zeitschrift des Vereines Deutscher Ingenieure*, and translated into English units. The data for these curves were taken from tests made of two different boilers under conditions as near alike as possible in actual practice. One of these boilers, a watertube boiler, had a large surface exposed to the furnace—i. e., a large heating surface to receive heat by radiation. It will be noted that both boilers gave the same final flue gas temperature = 450 degrees F., but the boiler with the smaller amount of heating surface exposed to the furnace required 1,050 square feet of heating surface to do exactly the same amount of work as the boiler with large radiating surface did with 850 square feet of heating surface.

These tests and formulæ show why such boilers as the locomotive and "Delray Sterling" types give such a good efficiency at very high rating. These boilers have comparatively large surfaces directly exposed to the fire and furnace walls and in contact with the hottest gases of combustion—at high ratings the furnace temperature is very high—hence a very large percentage of the heat absorbed is transmitted by radiation in accordance with the formula given above.

There is little information available on the subject of "Transmission of Heat by Radiation in Steam Boiler Practice." This subject is worthy of considerable investigation and experiment in order to secure more information which will help to design boilers for a higher efficiency of heating surface. ENGINEER.

Piece Work

I have noticed several articles in recent issues of THE BOILER MAKER which are in favor of piece work. I have had some experience in piece work both as a journeyman and as a foreman, and know that if you have the right kind of men—that is, good mechanics and honest men—it is all very well, but when these factors are wanting there is trouble ahead.

An instance of what happened to me in this direction a few years ago may be of interest to your readers. We had a superintendent that had been working in a piece-work shop before he took charge of our shop, so, after he got "warmed in the nest," he was anxious to have the work in our shop done according to the piece-work system. He tried it first with the boiler makers. They were to get a certain amount for riveting with a gun and the calkers were to get a certain amount for calking, but the scheme did not work, so he tried it in the sheet-iron department. I advised him that this could not be done satisfactorily, as the boys in the sheet-iron department were doing all they possibly could, but he insisted that either it must be piece work or the boys must quit, so they quit. These young men had been working under me for several years, and I knew just what they could do.

When the boys quit I went off on a short vacation, but came back a few days before I expected to, and when I came down to the shop I found that things were rushing. The superintendent had taken boys off the street to run the punches according to the piece-work system, and the results were even worse than I expected. They were punching holes all over the plate, hardly any of them in the center marks. The plates were for a line of water pipe and the riveter was to get a certain amount for seaming up and a certain amount for the girth seams. As a matter of fact, there were very few fair holes. They would get one hole fair, others a quarter off, others a half off, and still others where only the edges of the holes would come together. The rivets were driven on a stake riveter, and all they had to do was to put the rivets in the top hole and the plunger would crush them down through the unfair holes. When I came to look at the finished work, there wasn't a single seam, either longitudinal or girth, but where most of the rivets had to come out, the holes cut out, and the rivets driven again by hand.

I went to one of the boys who did the punching and told him to get the punch on the center mark before he punched the hole, but he told me that he could not make his salt if he did it that way. I called this to the attention of the superintendent; but he said that it was all my fault, as I was against the piece work. Now I was not against piece work if the work could be done better and quicker, but in this case the boys I had before were working the punches for all they were worth, and I knew I could get no better work nor quicker work out of any of the others.

To get good results with piece work in a boiler shop the men must be honest, skillful and willing to do piece work. You can't get good work by driving them to it.

Springfield, Ill. JOHN COOK.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

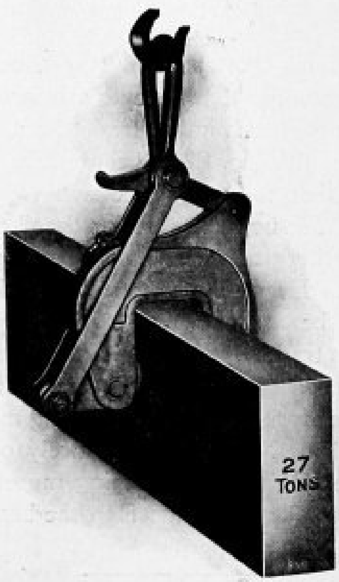
It is a regrettable circumstance that such a large percentage of boiler shops at the present time still adhere to the old-fashioned system of apprenticeship in the training of their employees. Years ago in almost every trade the apprentice was thrown almost wholly upon his own resources to pick up a working knowledge of his trade. He was given employment on a minimum scale of wages, and the humdrum tasks in the shop were his portion of the labor. His chief opportunity to learn the trade was to watch and imitate the other workmen, without delving very deeply into the whys and wherefores of the processes or methods. It was not long, of course, under such circumstances before a boy with average ability and perseverance became well acquainted with the ordinary tools of his trade and attained sufficient proficiency and skill in their use to be intrusted with some of the everyday work. The process of gaining the efficiency of a skilled workman by such methods, however, is slow, and much depends upon the kind of workmen with whom the apprentice comes in contact. It has always been true that here and there some of the older men in the shop are always ready and willing to give freely of their time and experience in helping the younger men climb up the lower rungs of the ladder; but such cases are the exception rather than the rule, and no matter how willing the skilled workman may be to give assistance, it is beyond his power to undertake a systematic and thorough course of instruction except for one or two of the boys. He can answer questions, give suggestions and advise as to the work; but in order to profit by it the apprentice should have some foundation of the fundamental principles of his trade on which to build. In the boiler making trade, especially, many of the boys who come into the shop to learn the trade lack even a working knowledge of arithmetic, which they should have acquired in the public schools. The use in a boiler shop of arithmetic, or any of its allied subjects, may not be apparent to an apprentice in the early days of his work; but by the time he has advanced far enough so that his eyes are focused on some of the higher positions in the trade the need of it and of many other things will be keenly felt. It is not to be supposed that the apprentice will voluntarily take up the study of such subjects, or that he will choose well in his methods of study, unless someone is at hand to guide him. Even then the success of the undertaking will not be assured until he really becomes interested in his trade beyond the point of his daily wage. To accomplish a successful system of training apprentices, therefore, requires something more than the old-fashioned methods not yet entirely out of vogue and the development of something more comprehensive and better adapted to develop the best there is in the boys.

In the article on "Boiler Explosions" published in this issue a point which we have repeatedly put before our readers is again emphasized. This point relates to the necessity for uniform laws for the construction and inspection of steam boilers throughout the country. It is conceded that the few States which have already established boiler laws have taken a wise step, but also it must not be forgotten that in the comparatively few instances where this end has been accomplished there is an unfortunate lack of uniformity in the rules formulated, so that both the boiler manufacturer and the steam user are placed at a disadvantage in doing business in different States. A step in the right direction in the effort to overcome this discrepancy and secure uniformity in boiler laws has been made by the American Society of Mechanical Engineers in the appointment of a commission, consisting of representatives of steam users' interests, steel manufacturers' interests, boiler manufacturers' interests and boiler insurance interests, to prepare a standard code for the construction and safe operation of steam boilers. This commission is at present engaged in the preparation of such a code, and the result of its work should prove a valuable instrument for all interests concerned. Such a code, of course, cannot have the prohibitory effect of a law, yet it is certainly a step in the right direction, and undoubtedly steam users and boiler manufacturers will not hesitate to take advantage of such a guide to bring about more complete uniformity in boiler practice.

New Improved Engineering Specialties for Boiler-Making

Positive Patent Lifting Clamp

A lifting clamp made both for lifting and for hauling in any capacities ranging from ½ to 50 tons; for handling plates, beams and structural shapes for use in steel works, rolling mills, boiler and tank shops, iron and brass foundry annealing



furnaces; for railroad and steamship companies in loading and discharging, and, in fact, for all purposes where a positive and reliable clamp is required, avoiding the danger of swings, ropes, etc., besides effecting a large saving in time and labor, has been placed on the market in England by the Weldless Chains, Ltd., Coatbridge, Gartsherrie, and in America by William E. Volz, 126 Liberty street, New York. The clamp is made in various sizes, the one illustrated being supplied for lifting armor plates 9 inches thick and weighing 27 tons. The clamps are made from mild steel castings and forgings with a tempered steel serrated piece dovetailed to the side of the gap frame. The gripping cam is also tempered on the working face. It is claimed that the grip is instantaneous and positive, and the heavier the load the firmer the hold.

Forging Presses

Makers and users of heavy forgings are inevitably forced to the conclusion that press work is better than hammer work, unless the hammer be made of unwieldy proportions. Wherever we turn, hammers are being replaced by presses for heavy work with few exceptions, and these will soon follow.

While hydraulic accumulator presses have been in use in the United States for several decades, the steam hydraulic, or direct acting intensifier press, is of rather recent origin and has been developed in Europe. The success of this type on the other side of the Atlantic has caused several American manufacturers to take up this class of work. The press described herewith was originated by the firm of Haniel & Lueg, of Dusseldorf, Germany. The exclusive right of building these presses in the United States and in Canada was acquired, two years ago, by the Mesta Machine Company, Pittsburg, Pa.

Fig. 1 shows two of the presses built by this company for general forging purposes. It will be noticed that the press is accessible from all sides for the use of shear tools, die holders, etc. Fig. 2 shows a front elevation of the press with a sectional view of the cylinders. The press consists of a heavy base, *U*, four columns, *X*, and the stationary crosshead, *Y*, which contains the hydraulic cylinder, *P*, and the hydraulic balancing cylinders, *F*. The pistons of the balancing cylinders *F* are connected to the movable crosshead *H* by the piston rods *G*. The pistons of the steam cylinders *R* are connected to the extension of piston rods *G*. The air chamber *W* is partly filled with water and is connected to hydraulic cylinder *P* with check valve *V* in the connecting pipe. The balancing cylinders *F* are connected directly to the air chamber. *A* is a

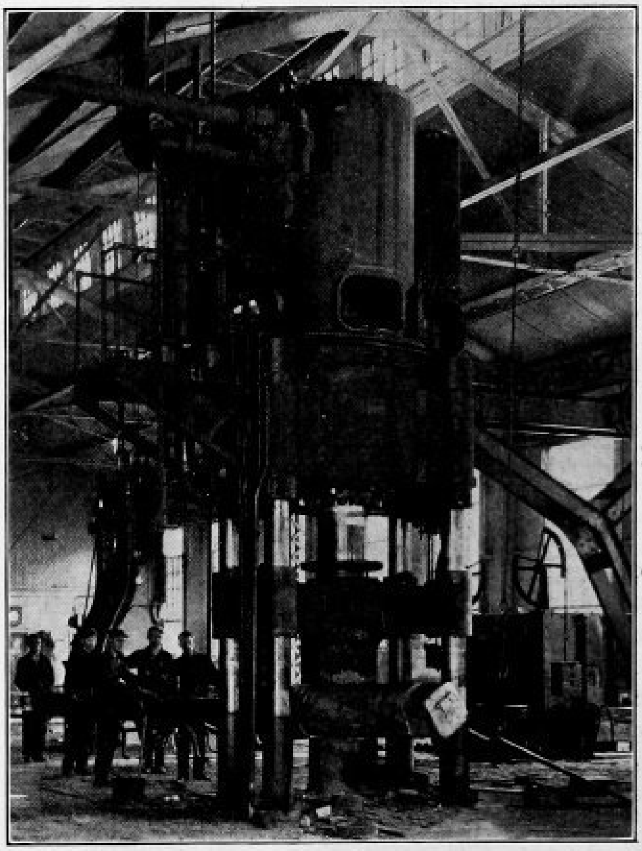


FIG. 1

single-acting steam cylinder. *T* and *S* are the top and bottom dies.

Hydraulic cylinder *P*, balancing cylinders *F* and about one-third of the air chamber *W* are filled with water. The air chamber is then pumped up to a pressure of about 100 pounds, which is sufficient to move piston rod *C* and piston *B* to the top of the steam cylinder *A*, when there is no pressure in the steam cylinder. The pressure on plunger *D* is always balanced, as the area of the two cylinders *F* is equal to the area of cylinder *P*. By admitting steam to cylinders *R* the crosshead *H*, which contains die *S*, can be moved upward to any point by lifting check valve *V* and allowing water from cylinder *P* to flow into air chamber *W*. When die *S* is at the proper height, check valve *V* is closed. The press is then ready to take the piece to be forged between the dies *S* and *T*. By admitting steam to cylinder *A*, piston rod *C* is forced into cylinder *P*, which gives the necessary pressure to do the forging. As soon as the steam is exhausted from cylinder *A*, piston *B* and crosshead *H* automatically move their positions ready for the next stroke.

The all around accessibility of the press and the small requirement of floor space are coupled with a slightly greater requirement for head room. It has long been realized that

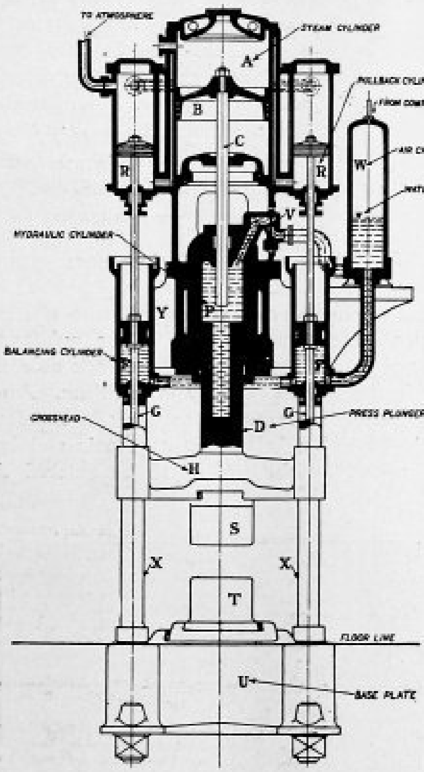


FIG. 2

the hammer is out of the race in flanging processes; for this purpose presses are in general use. Here the survival of the fittest and the trend toward simplicity and direct action open a wide field to the steam hydraulic press. Fig. 3 shows a

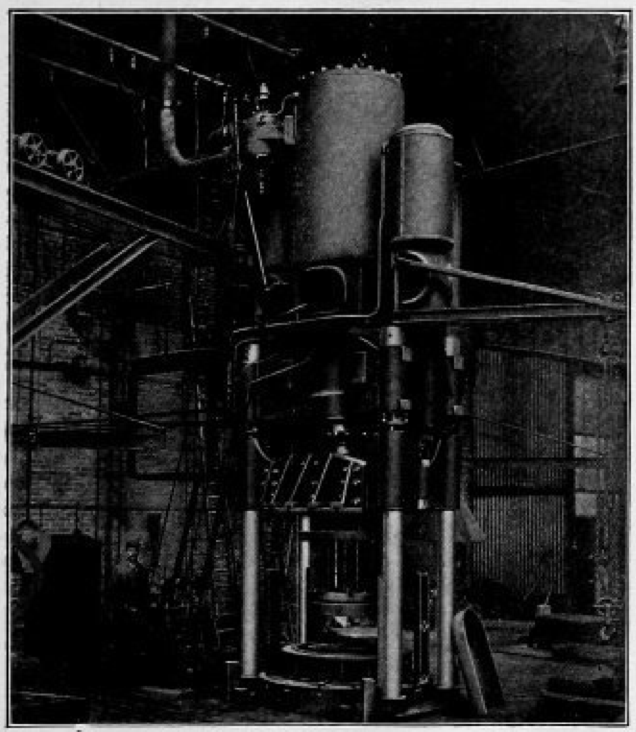


FIG. 3

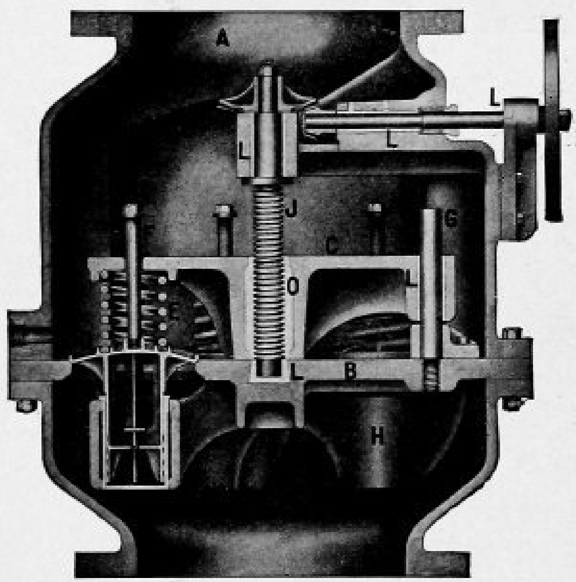
flanging press (Mesta-Haniel & Lueg system) with steam and pull back cylinders, centrally arranged over the hydraulic cylinder. This type of press is adapted particularly for the flanging of boiler heads or similar press work in a boiler shop.

Cochrane Multi-port Safety Exhaust Outlet Valve

The Cochrane multi-port safety exhaust outlet valve is one of the latest products of the Harrison Safety Boiler Works, Philadelphia, Pa. This valve is designed to meet an insistent demand for a "fool-proof" valve which can be relied upon, and also allow easy and quick regulation to varying degrees of back pressure.

An exhaust outlet valve is in effect a safety valve intended for low-pressure service. It should be so designed that it cannot be overloaded, and the makers have, therefore, used nickeled steel springs and dispensed entirely with all exterior weights which are subject to interference by unauthorized persons, or to accidental obstruction.

To provide against possibility of sticking a number of disks are used even in the smallest size. Single disk valves have been known to stick and blow up the heater or other apparatus to which they were attached. Each disk is provided with a dash pot on the in-take side, which is automatically kept filled with water of condensation, thus cushioning the valve.



By this means all hammering or clattering, it is claimed, is avoided.

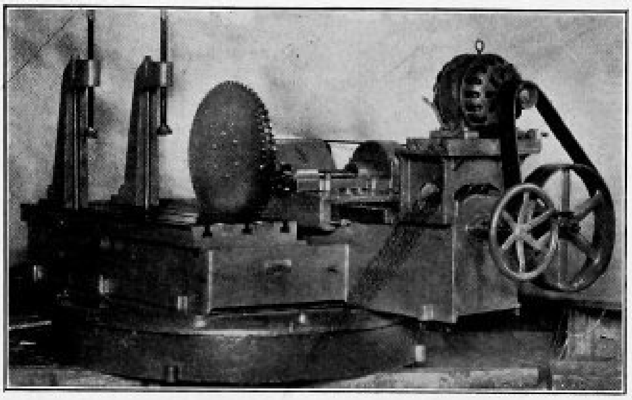
The downward motion of the pressure plate is limited, thereby fixing the maximum pressure to which the disks may be subjected, and hence the maximum back pressure that can be carried is absolutely determined. It is claimed that the valve can't be tied down. If a definite increase of back pressure is authorized, however, it may be made by putting in heavier springs.

By raising the pressure plate all the disks are lifted off their seats, thus providing free exhaust to the atmosphere. The loading and unloading of these valves is so easy that it can be performed frequently; that is, the engineer can carry heavy back pressure in the morning when the heat is needed, and release it in the afternoon, thereby reducing the steam consumption of the engine and saving coal.

All adjustments are easily made by turning the hand-wheel on the valve. A chain may be connected from the valve on the roof to the boiler room, and the engineer is thus put to no trouble to adjust it.

Combination Saw and Rotary Planer

A machine which is found very useful in a structural shop is shown in the accompanying illustration. It is a combination saw and rotary planer mounted on a circular base, the particular machine illustrated being of the 4-B type, which has just been shipped by the Vulcan Engineering Sales Company of Chicago to the Northwest Steel Company, Portland, Ore. The machine is mounted on a circular base and permits cutting long pieces of material from any angle in the shop, which is a valuable feature in a shop where space is limited. The machine is motor-driven, connected by a belt to the motor



instead of being direct connected by gear and pinion, as this type of drive has proved to be an additional factor of safety. Either a milling head or saw blade can be attached to the machine, thus practically combining two machines in one, and thus cutting down the expense of installing separate machines for the two purposes. The machine illustrated carries a 31¼ inches diameter saw blade, or a milling head 28¾ inches diameter of cutters for the tools. The saw blade carriage has a travel of 36 inches, and the saw blade runs at about 28 feet per minute. The machine has a capacity for 12-inch rounds, 10¾-inch squares and 24-inch I-beams. The feed is of the adjustable variable friction type, changeable at all times from ¼ inch to 1 inch per minute. The machine is fitted with an adjustable stop provided to stop the carriage at any desired point of travel.

Personal

C. A. CARSCADIN, formerly connected with the Globe Seamless Steel Tubes Company, has become general sales manager of the Spencer Otis Company, Chicago, Ill.

THOMAS LEWIS, who for the past six years has held the position of master boiler maker for the Lehigh Valley Railroad, was promoted Oct. 1 to the position of general foreman of the system's shops at Sayre, Pa.

J. A. COXEDGE, formerly assistant foreman boiler maker on the Atchison, Topeka & Santa Fe Railroad at Albuquerque, N. M., has been appointed general foreman boiler maker of the Southern Pacific system at El Paso, Tex.

GEORGE H. EMERSON, who has just been appointed general manager of the Great Northern Railroad, has had a most interesting career. He is stated to be the first boiler maker who has reached the position of general manager of a great railroad. Mr. Emerson is only 42 years of age, and is a first-class boiler maker, having worked in a boiler shop for eight years. He started as water boy on the Willmar division during the summer of 1880. In 1882 he became an apprentice in the St. Paul shops, and after five years a boiler maker. From September, 1890, to February, 1892, he was fireman and engineer on the Dakota division of the road, and was locomotive foreman at Glasgow, Mont., in 1895. After two years' service there he was appointed general shop foreman and master mechanic of the Dakota and Northern division. From Jan. 1, 1900, until Jan. 10, 1903, Mr. Emerson was general master mechanic for the Western division. He became superintendent of motive power on the Great Northern System January, 1903, and in March, 1910, was appointed assistant general manager.

HENRY W. JACOBS, one of the inventors of the Jacobs-Shupert sectional fire-box, was born in Atchison, Kan., Sept. 28, 1874, his parents having emigrated from Germany in the early sixties. He was educated in the public schools of Atchison, and at the age of 13 began work as a machinist's apprentice in the Seaton foundry in Atchison. After serving his apprenticeship he continued to work in the foundry, improving his education in the night schools and by studying technical books. At the age of 18 he entered the United

HENRY W. JACOBS

States gun shop in Washington, D. C., as a machinist, and later he was admitted to the engineering department of the navy, where he became familiar with marine machinery. His knowledge of various kinds of machinery was greatly broadened by subsequent employment with manufacturers of electrical machinery, printing presses and steam engines. In 1890 he began his railroad career as a machinist in the shops of the Burlington Railroad, from which position he worked his way up until in 1906 he was appointed assistant superintendent of motive power of the Santa Fe. His work in connection with shop demonstration and shop methods resulted in the reorganization of all the tool rooms of the Santa Fe and placing them on a satisfactory basis. Mr. Jacobs developed an efficient system of wage payment, and became a valued contributor to the technical press, one series of his papers on "Betterment Briefs" being subsequently published in book form. During his career he has invented a number of improved mechanical devices besides the sectional fire-box, including an excellent track repair and inspection car, a locomotive superheater and certain features in the development of oxy-acetylene welding.

Communications of Interest from Practical Boiler Makers

The Crank

It often happens when a boiler maker is sent out on an outside repair job that he meets a crank, ignorant or unreasonable, in the person of the owner or superintendent of the boilers he has to repair. I would like to give the readers of THE BOILER MAKER a little of my experience with such cranks.

Some few years ago I was ordered to get myself and my tools ready for a trip of some 60 miles out into the foot hills of the Allegheny mountains on a steam shovel job. The time was winter, the month February, and it was intensely cold with a regular blizzard blowing.

Arriving at the station where the first change was made I met with the first unpleasant jolt. It was supper time; but the shovel foreman wanted me to continue the journey without supper. Here I registered my first kick and got my supper. Then began a journey of 10 miles across country on a bob sleigh in a blizzard the like of which has not been seen in Western Pennsylvania in the memory of man. It was too cold to ride, so we had to grab the back of the sled and walk to keep from freezing. About 9:30 P. M. we arrived at the shovel, and here I got my second jolt, for I found the crew busily engaged removing the flues. I was asked to go to work at once, but told them that I would not do so even for my grandmother, and I loved the old lady very much, so I was taken to the camp boarding house, one of the kind usually found in construction camps, made of slab boards and tar paper.

By morning the temperature had fallen to 30 degrees below zero, and the country looked more like the Arctic regions than Pennsylvania. Just after getting well started replacing the flues I got another jolt. One of the contractors wanted to know how long I was going to be on the job. I told him it was impossible to estimate the time, as the working conditions were entirely different from what I had been accustomed to; but, like all other cranks, he insisted upon knowing approximately how long it would take me, so finally I told him that if everything went well I would put them in at the rate of about five flues per hour, there being 126 2-inch flues.

The working conditions were as follows: The shovel boiler was one of the vertical type with a raised crown sheet. All of the flues had to be cut to length, and the most you could cut at one time was two of the same length. All of the flues were set in copper ferrules, which were rolled in the flue sheet. The flues were all prossered, rolled and beaded, the shovel engineer rolling at the top or smoke-box end.

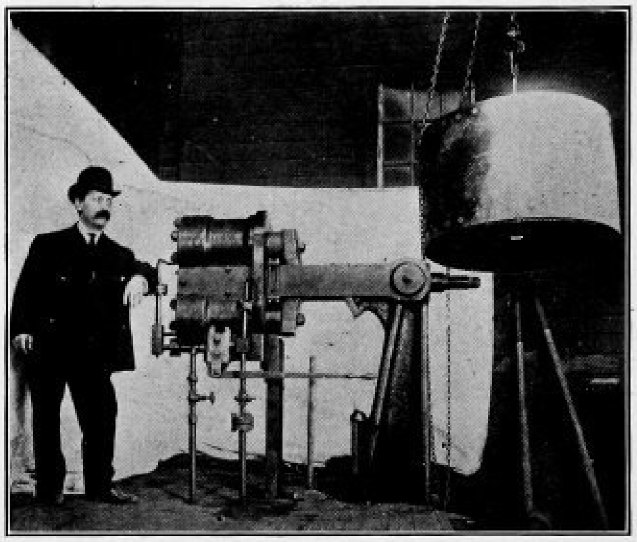
The job was completed and ready for test in just twenty hours, yet when the superintendent came to order me to get the measurements for another set of flues for another of their steam shovels he said we would have to make better time on the next job. I asked him if he expected me to put in the next set of flues, and he said he did, so I told him he would have to wait until the weather moderated. Can you imagine anything more unreasonable and cranky than to expect a man accustomed to work in a modern boiler shop, with all the conveniences, to work on a job of that kind in a cut 80 feet deep and with no other heat than that furnished by a small stove of the cabin-car kind and two gasoline torches?

The hardships that some of our readers who work in contract shops have to endure is beyond belief, and I think that the steam user should make the working conditions of the repair man as favorable as possible, and that the firm sending him out for this work should look into these things a little more closely than they do. On making my report to the shop manager, he said that he would send these people the flues, but that they must get a man from somewhere else to put them in, as he would not allow his men to be subject to such unreasonable treatment again.

FLEX IBLE.

A Home-Made Hydraulic Riveter

The accompanying photograph shows a home-made hydraulic riveter which may be of interest to the readers. In the first place, the riveter was a toggle-joint, 6-foot gap compressed air riveter, but the air cylinder became played out, the air pressure was limited and irregular, so I used the frame and made a hydraulic cylinder for it. The main cylinders are each 6¼ inches bore, and the pull-back cylinder is 3 inches bore. All of them are cast in one block; the operating valves are also cast in one block. The port holes are ½ inch diameter, drilled and plugged, and the valve stems are packed with hemp.



A SUCCESSFUL HOME-MADE HYDRAULIC RIVETER

After this machine was rigged up a large amount of small tank work came to the shop, and for this work a great deal less pressure was needed for the riveting, so I made two more cylinders, 3 inches and 3¼ inches bore each, and put them on as resisting cylinders, or, in other words, extra pull-back cylinders. They worked very nicely, and I was able to drive some fifteen rivets a minute. Even half of that number is a pretty good record on a larger machine.

The frame for supporting the cylinders consists of 1-inch by 6-inch bars, the housing ends of which fit over a 4-inch hub. The cylinder ends of the bars are turned over and welded, thus making a stop. A ⅞-inch bolt passes through bolt bars to hold them up in place.

JOHN BUTLER.

Troy, N. H.

Square or Clylindrical Tanks

My critic, G. A. S., in the August issue, is certainly justified in his stricture upon the lightness of plate quoted in my original communication in the July issue. The thickness given was as related to me, but did not appear in the correspondence referred to. The firm who ordered the tank did not specify gage, this being left to the tank maker to use his own discretion.

Since the criticism appeared I have gone further into the matter. The practice of one of the best-known British tank makers for stock articles is tabulated below. Tanks as here listed are made up in the black and galvanized after manufacture:

RECTANGULAR TANKS.

Capacity.	Dimensions.	Thickness of Plate.	List Price.
Gallons.	L. W. H.		
250	60" x 36" x 32"	14 S. W. G.	$21
500	60" x 48" x 48"	12 S. W. G.	40
500	96" x 45" x 32"	12 S. W. G.	40
1000	108" x 60" x 43"	1/8" plate	75
2000	Customer's	3/16" plate	Special
3000	Customer's	1/4" plate	Special

CYLINDRICAL TANKS.

	Diam. Height		
250	38" 60"	14 S. W. G.	$26
500	48" 76"	14 S. W. G.	40
1000	60" 96"	1/8" plate	85
2000	Customer's	3/16" plate	Special
3000	Customer's	1/4" plate	Special

The prices in each case are subject to the same discount.

I disagree entirely with my critic's statement that a rectangular tank can be built to stand without bulge even if properly distributed tie bars are used. Internal pressure is not in question. The type of tank under discussion is best described as an open top cistern. The fact is that bulging does take place in the usual commercial rectangular tank even with proper tie bars. Naturally, if a tank is built of the scantling usual to a boiler, bulging could be obviated, but such method of construction is absurd when it is borne in mind that the same scantlings as used for rectangular tanks when used in a cylindrical form stay themselves without bulging.

Another error G. A. S. makes is that rectangular tanks cost more than cylindrical. This is contrary to fact if each type is built of the same gage plate. The tabular statement given above disposes of this contention.

Rectangular tanks of the description indicated are made up of sheets having one or more edges flanged cold with a good radius; seams are close riveted. Corners where three plates intersect have a triangular hole developed by the flanging. This hole is filled by a rivet of large size hammered down hot. Top edge of the tank is finished with light angle iron, not welded at the corners, simply cut. A gusset piece placed across the corners and riveted to the angles forms the necessary corner stiffener.

Tie bars are 1/2 or 5/8 inch round bar with roughly flattened ends, attached to small pieces of angle, which in turn are riveted to the side of the tank. The number of tie bars usually employed is as follows: 500 to 1,000 gallon tank, 3 tie bars; 2,000 gallons, 5 tie bars, and 3,000 gallons, 7 tie bars.

The proportional dimensions of the tank affect the distribution of the tie bars. In the case of a shallow, long tank, say 1,000 gallons, two tie bars are placed equidistant at the mid section of the tank, and one forms a stay at the center of the top.

The extra cost of cylindrical over rectangular tanks is due to the welded ring of angle iron at the base and top. Angle smithing is expensive even when in quantities, and these rings add considerably to cost.

For storage purposes where floor space has to be studied, there is an apparent gain in the use of rectangular tanks. These latter for equal capacity are cheaper, as shown.

If, however, constant calibration per inch of depth is required or is of importance, then the cylindrical tank is worth while. For oil storage tanks, or for testing purposes where proportional depth indicates capacity or quantity used, the cylindrical tank is a "sine qua non."

The round tank also suffers less from abuse and does not dent easily. The tie bars in a rectangular tank are fitted to minimize bulging due to the pressure resulting from the standing liquid, and do not prevent denting due to abuse or accident.

From a floor space point of view the argument in favor of the rectangular tank seems valid, but even so an analysis of commercial conditions renders it less effective. Rectangular tanks are usually made less in height than in length or width, and the cube is the extreme dimensions usually employed considered as extreme height. Utilizing ordinary usual commercial thicknesses, increase in height beyond this results in excessive bulging, while the cylindrical tank may be made any reasonable height without bulging at all.

In his comparison of the respective merits of both types of tanks, my critic assumes a rectangular tank 60 inches by 60 inches by 96 inches, the longer dimension being height. Such dimensions are unusual and would involve considerable increase in gage of plate employed; that is, commercially considered. Further, to make the comparison more startling, he proceeds to sacrifice 5 inches in diameter of the circular tank by assuming a 2½-inch angle placed outside at the top and bottom.

Needless to say, the welded angle rings in a circular tank are invariably placed inside, and the exterior diameter of barrel is the extreme dimension. Where a cylindrical vessel is exposed to internal pressure, such a construction is usual, but we are discussing storage tanks. The bottom of the cylindrical tank is a flat circular sheet slightly less in diameter than the diameter of the barrel riveted to the internal flange of the ring. A loose cover can be secured in a variety of ways to the internal flange of the top ring. Hook bolts for a flat cover, or a simple bridge bar with a center bolt for a dished cover, can be employed.

The calculations given are thus misleading for a battery of tanks relative to floor space. A 60-inch by 96-inch circular tank contains 1,000 British gallons, a rectangular tank of similar overall dimensions (quite unusual sizes) would contain 1,250 gallons, an increase of 25 percent only and not 50 percent, as my critic points out.

Taking the dimensions of rectangular tanks of light gage usually made and stocked, the cube representing the usual extreme, then 65-inch cube contains 1,000 gallons, giving in the battery the larger capacity to the cylindrical tank.

One other point with regard to the apparent sacrifice of floor space due to cylindrical tanks. If the battery of storage tanks be double banked—that is, in double rows with access between each row—the tanks can be staggered if cylindrical, and so again minimize the percentage increase in capacity due to rectangular tanks being employed.

The matter is not quite so simple as would appear from *G. A. S.'s* article, and many more considerations are involved. If a step is taken outside everyday manufacture the cost runs up in a quite alarming manner.

In conclusion, may I point out that quite satisfactory storage tanks are now being made corrugated? Circular corrugations similar to those in roofing sheets are rolled into the body sheet of circular tanks. The stiffening imparted by such corrugation enables a much lighter gage to be used. A 96-inch by 60-inch cylindrical tank of this description has the body sheet 22 S. W. G., with the bottom of 18 S. W. G. Such tanks are exactly half the cost of equal capacity tanks made plain. Naturally such tanks cannot be employed where calibration is necessary. Very large quantities of such tanks are being made at the present time. Their extreme lightness for transport and very low cost, together with the satisfactory results of their use, cause an increasing demand year by year.

London, England. A. L. HAAS.

Talks to Young Boiler Makers

Quite a number of my boiler-making friends have asked me about gas engines, or what are called "internal combustion engines." They seem to think that the introduction of these engines will drive out boilers and that there will be no boiler work for them or for their sons who follow them. There is no doubt that small steam plants are not as much used as a few years ago, but the electric motor, which largely takes its place, must be run with steam power, usually. Of course, water power is furnishing electric power and the water power of the country will be more and more used. Yet I cannot see that the boiler business of the country will fall off; in fact, I think more boilers will be built in the next five years than there have been in the last five. No matter whether the steam turbine or the regular engine is used, the boiler must be behind them, but in larger units; and in a thousand and one places must steam be used for purposes other than power producing, which strengthens my belief that the boiler maker's trade is in no danger of going out of business, so I would advise young men to learn the trade, but to learn it well.

I have been very much surprised to be asked by young boiler makers about decimals, so I am going to say a few words on the subject, as it seems to me that those who are puzzled by them can be set right with little difficulty.

Now, every boiler maker uses decimals all the time and never gets twisted, for it is the system used in the money he gets paid with and he doesn't make many mistakes about that.

In his trade the boiler maker uses a rule, or scale, which has on it what we may call "natural divisions"—that is, it is natural to divide a piece of string into halves by doubling it, and by continuing to double it to obtain quarters and eighths, sixteenths and thirty-seconds. The twelve inches in a foot can be divided by 2, 3, 4 and 6 and have even inches. One would have thought that an inch would also have been divided into twelve parts also, but it is divided into eighths, and in the minds of most Americans an eighth or a quarter of an inch means something. It is not natural to divide things into tenths, which is the decimal system. Take our piece of string. It would be a hard job to divide it into ten equal parts, yet the decimal system has great advantages, and, as time goes on, our twelve inches and its eight divisions will pass away and only decimals will be used.

To show the value of decimals, let me say that the decimal point is its danger and value. It's just a period like this (.). It has not value itself, but it entirely changes the value of a set of figures by its position. It is the point of departure. The more figures there are to the left of it, the greater is the value, and the more figures there are to the right of it, the less is the value. We will take an example, the two figures 55. Now, if the decimal point is put to the left, thus .55, it is read 55 hundredths; if the point is between the two fives, it is read 5½, and the value of the figure to the left is increased. In the first reading you would have 55 cents, and in the second reading you would have 5 dollars and 50 cents; quite a change, and, if the decimal point was put after the right hand 5, you would have 55 dollars, a still better condition. From this you can see that my statement is true, that the decimal point is dangerous if you get it in the wrong place.

Decimals are much easier to multiply or divide than fractions. But let us see how we get at decimals; ¾ is a fraction and we want to make it a decimal. We divide 100 by the lower figure 4 and get 25 for an answer. We then multiply this result, 25, by three, and we get 75, which means 75 one-hundredths, or, if written as a decimal, .75; or, we can divide the upper member by the lower, thus, $3 \div 4 = .75$. Of course you will say, how can you divide 3 by 4? We do it this way: We put a 0 to the right of the 3, making it 30, and 4 can be divided into it, but it will leave a remainder of 2, so we add on another 0 to the right of 30, making 300, and bring down the second 0 and make the 2 a 20, and this is divided by 4 five times, leaving no remainder, and our result is 75. But where are you going to put the decimal point? You must start from the right and count as many figures to the left as there are more figures in the amount divided than there are in the figure you divide by. There is one figure only in what we divide by, called the divisor, while there are three in what we divide, called the dividend, so we have two more figures in it than in the divisor, and counting from the right we put the decimal point before the seven, making the result .75.

I told you about the figures 3.14159, called π, pronounced "pi." If you want to get the circumference of a 4-foot boiler, you multiply this figure by 4, and you get 1256636. But how about the decimal point? You must count from the right as many figures as there are to the right of the decimal point in both figures used. Here there is only one decimal point and there are five figures to the right of it; so, counting from the 6, the decimal point will come to the left of the 5, and you would find your boiler measured 12 feet and 56 hundredths, or a little over 12½ feet in circumference.

When you add decimals the decimal points must all come under each other even in the answer. To illustrate, add the following figures:

$$\begin{array}{r} 3.14159 \\ 2.452 \\ 6.425 \\ 3.220 \\ \hline 15.23859 \end{array}$$

Also, when you subtract decimals you keep the decimal point in line, as below:

$$\begin{array}{r} 8.563 \\ 2.365 \\ \hline 6.198 \end{array}$$

Or, to put it clearly, in adding or subtracting decimals, keep the decimal points one above the other.

In multiplying decimals, point off from the right, in the answer, as many figures as there are to the right of the decimal points in *both* figures used. These two figures are called the multiplier and the multiplicand.

In dividing decimals, point off from the right as many figures as those in the divided figure exceed those in the figure it is divided by.

It must be remembered, in division of decimals, that the number being divided must have noughts added to the right of the decimal point if the figure which is being used to divide it has more figures to the right of its decimal point than it has. To illustrate: If we have to divide 16.143 by 2.14676, we would put it down 16.14300 divided by 2.14676, the two noughts being added, and they are brought down just as if they were figures. It is not my idea in saying these few words about decimals to try to make you believe, if you have understood me, that you now understand all about decimals, but to try and get you to study the subject with ease, but I hope I have shown you that the study is not difficult and that you are able to master it.

F. ORMER BOY.

Answers to Questions for Applicants for a Boiler Inspector's Job

In response to the request for answers to the list of questions for applicants for a boiler inspector's job printed on page 316 of the October number of THE BOILER MAKER, the following are submitted:

1. (*a*) In making an internal inspection of a boiler, I would examine the braces, tubes, flanges, water column openings, grates, blow-off valve and all piping; get the size and number of braces; the height of the segment of the boiler head; the size of the feed pump; then test the steam gage and safety valve, and, if necessary, apply a hydraulic test to the boiler.

(*b*) In making an external inspection of a boiler, test the gage and water-glass cocks, the water column, steam gage, safety valves and blow-off valves. Examine the boiler for leaks and see that the boiler room has a neat appearance and is in good order.

2. The safe working pressure of a horizontal tubular boiler 72 inches in diameter, 3/8-inch plate, 55,000 pounds tensile strength, would be:

$$55{,}000 \times \tfrac{3}{8} \times .72 \div \frac{72}{2} \times 5 = 82 \text{ pounds.}$$

In the foregoing calculation all the values are given in the problem except the efficiency of the riveted joints and the factor of safety. The factor of safety of 5 is chosen according to usual practice; the efficiency of the riveted joint is obtained as follows:

The strength of the solid plate for a length of one pitch of rivets is $\tfrac{3}{8} \times 3 \times 55{,}000 = 61{,}875$. The strength of the net section of plate between rivet holes is $(3 - 13/16) \times \tfrac{3}{8} \times 55{,}000 = 45{,}117$. The shearing strength of rivets is found by multiplying the area of a 13/16-inch hole which is .5184 square inch by 2 and multiplying the result by 44,000, which is the shearing strength of rivets in single shear. The result is 45,619. Taking the least of the values, which is 45,117 (the strength of the net section of plate), divide this by 61,875, which is the strength of the solid plate, and the result is .72, the efficiency of the joint.

3. The safe working pressure of the above boiler with butt strap construction with rivets pitched 6½ inches and 3¼ inches respectively, would be

$$55{,}000 \times \tfrac{3}{8} \times .85 \div \frac{72}{2} \times 5 = 97 \text{ pounds}$$

The only difference between this problem and the one in question (2) is the value of the efficiency of the joint, which in this case is a butt strap joint. Here the strength of the solid plate is taken for a length of the longest pitch or 6½ inches, and works out as 134,062. The strength of the net section of the plate at the outside row of rivets pitched 6½ inches is 117,304, while the strength of the net section of plate at the inside row of rivets plus the shearing strength of one rivet is 123,355. The shearing strength of all the rivets in one pitch works out as 114,048, which, being the least value of the different methods of failure, is divided by the strength of the solid plate, giving the efficiency of the joint as .85.

4. A firebox boiler with 7/8-inch staybolts, pitched 5 inches by 5 inches, with a staybolt value of 6,000 pounds per square inch, would be allowed 192 pounds safe working pressure. This is found as follows:

The area of a 7/8-inch staybolt at the bottom of the thread is .776. The area supported by one staybolt would be $(5 \times 5) - .776 = 24.224$. The strength of one staybolt would be $.776 \times 6{,}000$, or 4,656. Dividing 4,656 by 24.224, the safe working pressure is found to be 192 pounds per square inch.

5. For a boiler with 25 square feet of grate area I would recommend a 3½-inch safety valve. Rule: For every 3 square feet of grate area allow 1 square inch of valve area.

6. For a 150 horsepower boiler I would recommend a 5-inch by 3½-inch by 6-inch single cylinder feed pump.

7. The proper place for feed water to enter a horizontal boiler would be in the bottom at the back end. In a firebox boiler it would be at the front end on the sides. In a vertical tubular boiler it would be at the bottom.

8. The pressure allowed on any cast iron boiler, in my opinion, should not be over 25 pounds per square inch.

9. In determining if a 72-inch boiler with a 24-inch segment was properly braced, I would find the area of the segment, multiply it by the pressure, and divide the result by the value of the brace, allowing 2 inches above the flues and 3 inches from the flanges.

10. A 72-inch boiler with a 24-inch segment, carrying 125 pounds pressure would require 18 braces of 7,500 pounds value. Here the area of the segment is found by the following formula:

$$\text{Area} = \sqrt{\frac{D}{H} - .608} \times \frac{4 \times H^2}{3}.$$

According to this formula, the area of the segment works out as 1,057.95 square inches. Multiply this by 125, the pressure of the boiler, and divide by 7,500, the value of each brace, and the result is 17.6, meaning that 18 braces would be required.

11. In determining the efficiency of the ligament of a Maxim boiler, I would subtract the diameter of the flue hole from the pitch of flues and divide by the pitch. The efficiency of the ligament is usually from 25 to 35 percent of the solid plate, while the joint is usually from 60 to 70 percent.

12. I would attach the water column on a horizontal tubular boiler at the back end, connecting the top end on top of the boiler and the bottom end on the side of the boiler at the center. On a firebox boiler I would connect the water column at the back end, connecting the top end on the top of the boiler and the bottom end on the side about in line with the center of the cylindrical part.

13. The tubes in a horizontal tubular boiler are beaded because the flame comes in direct contact with them, and beading the tubes adds to the safety of the boiler by stiffening the head. In my opinion the tubes should be beaded at both ends.

14. I would consider it advisable to flare the tubes in a Maxim type of boiler, as it adds to the safety.

Grand Rapids, Mich. FRED CHINNOCK.

Boiler Inspection Rules

At the general session of the Inter-State Commerce Commission, held at its office in Washington, D. C., on Sept. 12, 1912, it was ordered that Rules 29 and 35, as approved in the order of the Commission entered June 2, 1911, be amended to read as follows:

Twenty-nine—Siphon.—Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam tight between boiler and gage. The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

Thirty-five—Setting of Safety Valves.—Safety valves shall be set to pop at pressure not exceeding 6 pounds above the working steam pressure. When setting safety valves two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 pounds they shall be removed from the boiler, tested and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock.

It was further ordered that the amendments to Rules 29 and 35 be made effective on and after Jan. 1, 1913.

Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,030,947. SPARK ARRESTER. THOMAS M. VAN HORN, OF CHICAGO, ILL., AND LOUIS E. ENDSLESY, OF LAFAYETTE, IND., ASSIGNORS TO AMERICAN SPARK ARRESTER COMPANY, OF INDIANAPOLIS, IND., A CORPORATION.

Claim 1.—The combination with a steam boiler provided with a tube sheet, a smoke-box, a smokestack leading therefrom, and an exhaust steam jet discharging upwardly toward the smoke stack, of a vertically disposed plate plate extending entirely across the smoke-box and secured to the tube sheet and extending forwardly therefrom in spiral form so as to provide a spirally disposed passageway for giving the smoke and gas one or more vertically disposed revolutions within the smoke-box. Three claims.

1,031,554. BLOW-OFF COCK. WALLACE W. HOFFMAN, OF JANESVILLE, WIS.

Claim 1.—A blow-off cock comprising a casing section, a nipple of comparatively soft metal, as brass, fixed to and extending beyond one end of the casing section and having its extended portion exteriorly threaded, means closing the opposite end of the casing section, with reference to the brass nipple, a valve body, of comparatively hard metal, opposed to the end of the nipple remote from the casing section, and a stem fixed with respect to the valve body and extending through the said means at the opposite end of the casing section. Three claims.

1,031,458. VALVE MECHANISM FOR DRAFT REGULATORS. JOHN MILTON, OF WASHINGTON, D. C., ASSIGNOR OF ONE-HALF TO EMIL L. SCHARF, OF WASHINGTON, D. C., AND ONE-HALF TO GEORGE F. EAMICH, OF LOVETTSVILLE, VA.

Claim 3.—A valve mechanism comprising a casing having air inlet and outlet pipes connected therewith, said casing having two vertical bores and two horizontal bores all in the same vertical plane, said vertical bores providing receiving and distributing chambers, and the horizontal bores providing valve passages, one of said chambers being provided with an exhaust port, the casing having a passage between the inlet and outlet chamber, an inlet in one of the valve passages to control the passage between the inlet and outlet chambers, an exhaust valve in the other valve passage to control the exhaust port, and an operating lever connected at one end with the exhaust valve and also connected at its ends with the inlet valve. Ten claims.

1,031,379. FURNACE-DOOR-OPERATING MECHANISM. SAMUEL D. ROSENFELT AND HENRY HELMHOLTZ, OF CHICAGO, ILL.

Claim 1.—The combination, with a furnace, of fire doors pivoted at their upper extremities to swing vertically, intermeshing gears on said doors concentric with their pivots, a fluid pressure cylinder, a piston and rod working therein, means for the admission and exhaust of fluid to and from said cylinder, an operative connection coupling the piston rod with one of the fire doors for coincidentally operating them, a manually operative lever journaled on the pivot of one of the fire doors, and a projection on said door in position to be engaged by said lever to impart opening movement to the doors. Six claims.

1,031,254. MECHANICAL STOKER. WILLIAM M. DUNCAN, OF ALTON, ILL.

Claim 2.—The combination with a furnace, of a wheeled stoker in the combustion chamber of said furnace, and tiltable track rails supporting said stoker whereby the rear end of the stoker may be raised and lowered, said furnace being provided with an abutment into proximity with which the rear end of said stoker may be moved to provide for said abutment serving as a barrier to the movement of the load on the stoker grate. Four claims.

1,031,249. LIQUID-FUEL FURNACE. GEROLAMO CONTI, OF GENOA, ITALY, ASSIGNOR TO SOCIETA ANONIMA ITALIANA PER LA COMBUSTIONE DEGLI IDROCARBURI, OF GENOA, ITALY.

Claim 1.—In a liquid fuel furnace the combination with the combustion chamber thereof, of a distributing pipe adapted to connect with a fuel storage reservoir, a grate comprising a plurality of troughs, each having a plurality of inclined steps in its bottom, and said troughs being arranged to incline from the mouth of the furnace toward the opposite end thereof, as described, and branch pipes leading from the said distributing pipe and adapted to discharge fuel onto the troughs. Three claims.

1,031,693. STEAM-BOILER SUPERHEATER. WILLIAM DALTON, OF SCHENECTADY, N. Y.

Claim 3.—The combination, with a locomotive boiler having a combustion chamber adjoining the fire-box, of a bridge wall interposed between the front of the grate and the front water wall of the fire-box, and a superheater located in the combustion chamber and having steam supply and delivery connections leading to the exterior thereof, between the bridge wall and the front water wall of the fire-box. Ten claims.

1,031,721. METHOD OF GENERATING STEAM. HENRY I. LEA, OF PITTSBURG, PA., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE COLONIAL TRUST COMPANY, TRUSTEE, OF PITTSBURG, PA., A CORPORATION OF PENNSYLVANIA.

Claim 1.—The combination with an internal combustion engine, of a heat-conserving agent adapted to convert heat energy into pressure energy, means for delivering the sensible heat of the exhaust gases from said engine to the heat-conserving agent, a primary source of gas supply, heat delivery means in communication with the primary source of gas supply and the heat conserving agent, and means dependent upon the pressure generated within said agent for controlling the flow of gas through said primary gas supply. Four claims.

1,032,015. DRAFT REGULATOR. CHARNOCK H. McCALL, OF ATLANTA, GA.

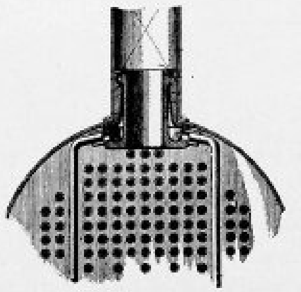
Claim 1.—The combination with a fire-tube boiler having the usual tube sheet and smokestack, of a baffle plate arranged adjacent said sheet, said plate comprising upper and lower sections slidably connected, the upper section being pivotally mounted at its upper edge adjacent the tube sheet, and means for swinging the baffle plate as a unit on such pivot toward and away from the tube sheet, and for simultaneously causing the lower section to slide on the upper so as to change the position of the two sections relative to each other. Two claims.

1,032,016. EXHAUST MECHANISM FOR ENGINES. CHARNOCK H. McCALL, OF ATLANTA, GA.

Claim.—A variable exhaust nozzle for engines comprising a hollow base or stand connected with the exhaust of the cylinders, and a pair of superposed annular rings hingedly supported upon said base, the hinges being disposed on opposite sides of said base, each of said rings being of frusto-conical shape, the large end of the lower ring being of the same size as and resting upon the top of said base, and the large lower end of the upper ring being the same size as and resting upon the small upper end of the other, and means for independently moving said rings relatively to each other and to the base. One claim.

1,031,748. EXHAUST NOZZLE. THOMAS P. WEBSTER, OF BRANDYWINE SUMMIT, PA.

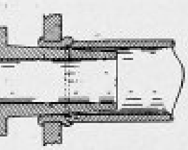
Claim 1.—An exhaust nozzle comprising a tubular portion formed with an annular channel at its inner end having steam inlet and with an inwardly tapering upper end, and a tubular portion fitted snugly within



the lower end of a smokestack to surround said former tubular portion to form an annular passage around the same and having its upper end annularly contracted to form a converging annular passage at the upper end. Two claims.

1,031,992. FLUE-PROTECTING PLUG. THOMAS C. FORD, OF TACOMA, WASH.

Claim 1.—In a device of the class described, the combination with a boiler plate; a flue passing therethrough and having an outward bead therearound adjacent the inner side of said plate, and a complementary groove within the flue; a removable ring of greater depth than said



groove and lying within said groove and extending into the inside of the flue at a point adjacent the inner side of said plate; and a removable hollow plug engaging said ring only and pressing outward thereon and extending outside of the flue to protect the end of the flue. Two claims.

1,032,723. APPARATUS FOR PREVENTING METAL INCRUSTATION. HENRY YOUNG, OF SAN DIEGO, CAL., ASSIGNOR OF ONE-THIRD TO CLAUS SPRECKELS AND JAMES E. WADHAMS, BOTH OF SAN DIEGO, CAL.

Claim.—In an apparatus to prevent boiler incrustation, a plate extending horizontally within the upper part of the boiler and out of contact therewith, curved arms extending downward from the edges of said plate, and substantially concentric with the walls of the boiler shell, an anode electrical terminal connected with the exterior of the boiler, and a cathode terminal attached to the plate, extending outwardly through the shell, and an insulating medium located in the shell, and through which the terminal connection passes from the plate. One claim.

1,033,007. LOCOMOTIVE-BOILER FURNACE. JAMES H. GROVE, OF OMAHA, NEB., ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., CORPORATION OF NEW YORK.

Claim 1.—A locomotive boiler furnace comprising a fire-box having a grate and provided with a flue sheet at one end and a fuel door at the opposite end in combination with a crown arch depending from the top of the fire-box and supported from the sides of the fire-box, said crown arch being adapted to introduce air through itself and project the same downwardly from the lower edge thereof, an inclined front arch between the flue sheet and the crown arch, said front arch containing air passages formed to deflect air downwardly adjacent to the lower edge of said crown arch. Three claims.

1,032,164. STOKER. WILLIAM H. H. STINEMAN, OF BALTIMORE, MD., ASSIGNOR OF ONE-THIRD TO ARTHUR WEGEFARTH, OF BALTIMORE, MD.

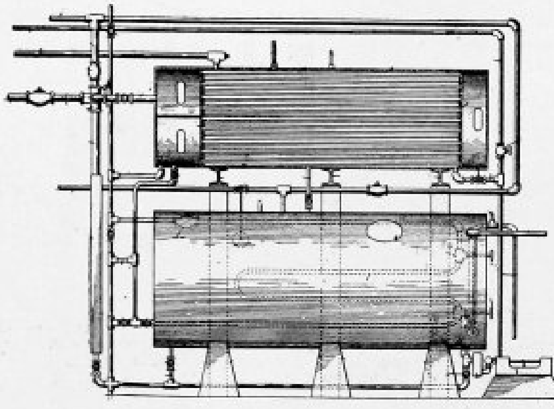
Claim 2.—In an underfeed furnace, the combination of a fire-box provided with a fuel support, a magazine within said fire-box having a discharge outlet to the fire-box, and spiral grooves or corrugations beginning near one side of said outlet and extending around and increasing in depth to the opposite side of said outlet, a hopper having communication with said magazine, a screw conveyor within said magazine and projecting into said hopper, adapted to be revolved in the direction of the increase of depth of the said grooves or corrugations, and means for operating said conveyor. Seven claims.

1,032,302. SPARK ARRESTER. DANIEL SCHNEIDER, OF SPOKANE, WASH.

Claim.—The combination with an engine boiler having a smoke-box and a stack communicating therewith, of an angular transverse partition dividing said smoke-box into forward and rear compartments, and separating the rear compartment from the stack, the rear compartment being in communication with the flues of the boiler, a horizontal flue tube carried by the partition and connecting said compartments, a deflector plate carried by the partition, extending horizontally into and having a length and width less than the length and width of the forward compartment, said deflector plate forming with the smoke-box an exit flue leading to the stack, and an exhaust tube arranged in the rear compartments and adapted to direct the exhaust steam from the boiler through the flue tube against the deflector plate, said plate having its free edges bent downwardly to deflect the heavy particles toward the bottom of the compartment. One claim.

1,032,076. BOILER WASHING AND FILLING SYSTEM. FRANK W. MILLER, OF CHICAGO, ILL., ASSIGNOR OF ONE-HALF TO CLARENCE D. BAUERS, OF CHICAGO, ILL.

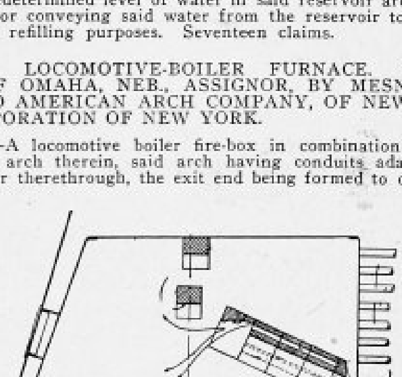
Claim 2.—A boiler washing and filling system comprising a filling water heater, a washout and filling water reservoir, a coil arranged in said reservoir, connections whereby the steam and water blown off from



a boiler are conducted through said heater into said coil, means for maintaining a predetermined water level in said coil, means for maintaining a predetermined level of water in said reservoir around the coil, and means for conveying said water from the reservoir to a boiler for washout and refilling purposes. Seventeen claims.

1,033,006. LOCOMOTIVE-BOILER FURNACE. JAMES H. GROVE, OF OMAHA, NEB., ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 3.—A locomotive boiler fire-box in combination with an inclined front arch therein, said arch having conduits adapted for the passage of air therethrough, the exit end being formed to deflect the air



downward toward the grate at about the center of the fire-box, a refractory arch bridging the fire-box above and back of said front arch and a further refractory arch dependent from the top of the fire-box above the second mentioned arch, restricted throats being formed between said arches. Seven claims.

1,036,494. SAFETY DEVICE FOR BOILERS. RICHARD J. HOGAN, OF POCATELLO, IDAHO.

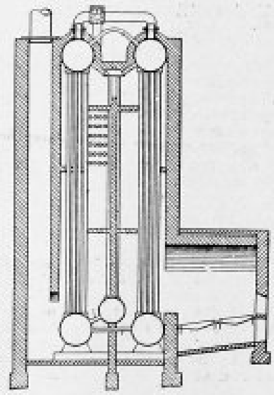
Claim 1.—In a device of the class described, the combination of a boiler, a pipe having one end projecting into the fire-box of the boiler and adapted to discharge onto the fire therein, and having its other end leading to the interior of he boiler, a piston-actuated valve for normally closing communication between said pipe and the interior of the boiler, and means for supplying steam to said piston and comprising a pipe extending into the boiler and having its end provided with closing means arranged close to a heating surface of the boiler, and said closing means being adapted to automatically open when said end is above the water in the boiler. Five claims.

1,036,616. AUTOMATIC DRAFT REGULATOR FOR STEAM-BOILER FURNACES. FRANK W. HARRINGTON, OF COVENTRY, R. I., ASSIGNOR TO WILLIAM K. LOGEE, OF PROVIDENCE, R. I.

Claim 3.—The combination with a steam boiler and the usual accessories, including a furnace provided with a firing-opening and a fire-door normally closing said opening, of a force-draft blower communicating with the furnace, means for actuating the blower, an electrical circuit having a switch element disposed therein, and means engageable with the fire-door and with said switch for energizing the circuit to temporarily render inoperative the blower-actuating means upon opening the fire-door. Four claims.

1,036,517. SUPERHEATER BOILER. JOHN E. BELL, OF BARBERTON, OHIO, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

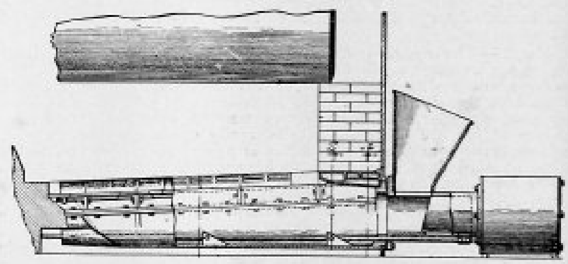
Claim 1.—A water-tube boiler comprising a setting, upper and lower transversely disposed drums, a pair of approximately vertical banks of tubes connecting the drums, a baffle between the banks of tubes forming up and down passes for the gases, a superheater having horizontal



tubes located in one of said passes between the water tubes therein and the baffle, a horizontal shelf on one side of the water tubes above the superheater, and a second horizontal shelf below the superheater on the other side of the water tubes. Two claims.

1,035,359. AUTOMATIC STOKER. WILLIAM J. KENNEY, OF CHICAGO, ILL., ASSIGNOR TO THE UNDERFEED STOKER COMPANY OF AMERICA, OF CHICAGO, ILL., A CORPORATION OF NEW JERSEY.

Claim 1.—In combination in a furnace, a retort for receiving fuel to be consumed, a beam supported by the front end of such retort and adapted to carry the weight of the front wall of the furnace, removable twyer blocks supported by such retort, and a deflecting plate adapted to



be supported by such retort over the entering fuel and under such beam, such deflecting plate adapted to direct the fuel upward in the retort and so conformed as to be insertable and removable from the rear of the front wall by removing the twyer blocks adjacent to such front wall. Seven claims.

1,036,983. TUBE CLEANER. WILLIAM S. ELLIOTT OF PITTSBURG, PA.

Claim 1.—A tube-cleaning device, comprising a tool proper having a plurality of radial blades or wings, and a coupling member, said member having a threaded shank projecting in one direction, and a hollow socket portion projecting in the opposite direction, and the tool proper having an integral anchoring portion which unites the rear ends of the blades or wings and is secured within said hollow socket portion. Two claims.

1,035,677. WATER-TUBE BOILER. HARRY F. BASCOM, OF ALLENTOWN, PA.

Claim 1.—In a device of the class described, an end wall having an opening; a partition extended across the opening and abutting against the wall; an imperforate plate removably held in the opening longitudinally of the opening and intermediate the sides of the opening, the plate abutting against the partition to prevent a cross draft through the opening; and a closure for the outer end of the opening, with which closure the plate engages. Three claims.

1,035,646. STEAM BOILER. MINOTT W. SEWALL, OF NEW YORK, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

Claim.—A steam boiler comprising a furnace, a bank of vertical heating tubes, lower and upper drums into which said tubes are expanded, a horizontal manifold supported above the upper drum, steam-supply pipes and superheating tubes connected to said manifold, said superheating tubes extending downwardly in proximity to the heating tubes and serving as a support for the front casing, a second manifold in which the lower ends of said superheating tubes are expanded, said last-named manifold being supported above the rear of the furnace roof, and a refractory covering for the lower ends of the superheating tubes extending upwardly from the lower manifold. One claim.

THE BOILER MAKER

DECEMBER, 1912

Autogenous Welding Applied to Fire-Box Construction

In the ingenious applications of autogenous welding to boiler and sheet metal work none is more important in the manufacture of boilers than an application which has been made recently of the Oxweld process in welding fire-boxes for boilers, so that all of the numerous joints in the fire-box which are ordinarily riveted and calked are eliminated, and manufacture of high and low-pressure fire-boxes instead of using the usual method of flanging the plates and joining them together with riveted joints.

Every boiler maker is familiar with the riveted fire-box shown in Fig. 1, so that this article will deal only with the reasons for using the welding process, the methods of construction and the results obtained from the welded fire-box.

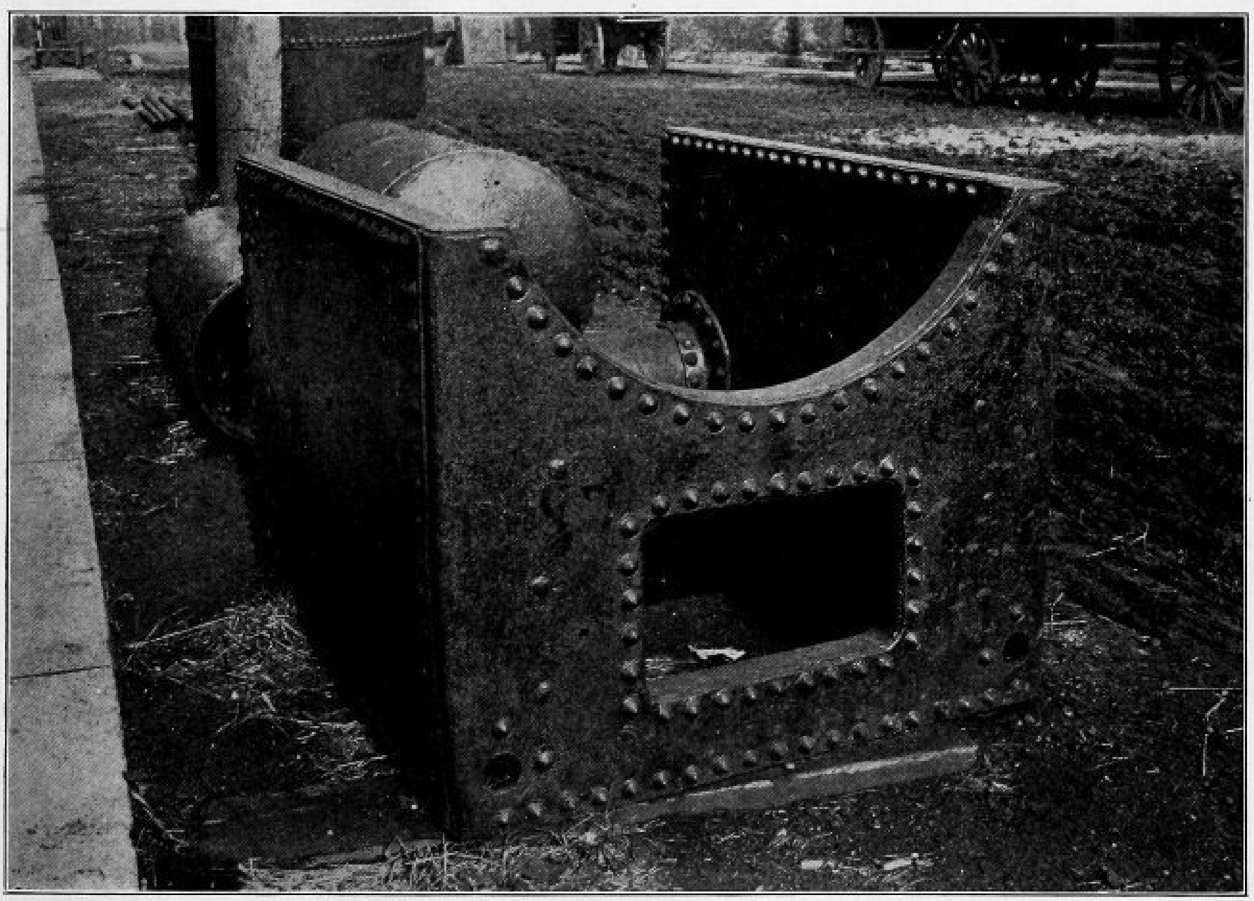


FIG. 1.—RIVETED FIRE-BOX

such difficulties as complicated flanging and calking and the use of cast iron mud-rings are entirely done away with. Fire-boxes which are thus welded throughout have been tested to 210 pounds water pressure with no failures in any of the welded joints, showing that the welded joints, if properly made, can be depended upon for strength as well as tightness.

The photographs and data given in this article were obtained at the shops of a boiler manufacturer in Chicago, where this process has already been used successfully in the manufacture of the water legs for heating and power boilers. This is said to be one of the first times that the welding blow-pipe has been applied in the vicinity of Chicago to the

Fig. 2 shows the construction of the welded fire-box, which, it will be noted, eliminates entirely the use of the 3-inch by 4-inch cast iron mud-ring, which is not only difficult to cast but is also difficult to drill for riveting and to set in place. By the new method of construction the two half sheets are bent to form the three sides of the fire-box, and the edges are dished over, extending 1½ inches, with ¼-inch bevel on each edge; the two halves are assembled ⅛ inch apart and then welded along the seam, which is in the center of the edges all around. This was the method of construction used on the first welded fire-box, but it will probably be changed in subsequent manufacture, so that each of the three sides of the fire-box will be welded separately, and then the four vertical and bottom edges will be welded together, as shown in Fig. 3.

This method of welding, of course, produces an absolutely tight joint, which requires no calking. It must, however, be carefully done in order that no weakness will develop in the welded joints. The cost of manufacturing the particular fire-box illustrated, which weighs 500 pounds, and on which there are 44 feet 8 inches of weld, was between $16.80 and $18. This cost will doubtless be reduced with practice and as improved methods of handling the fire-box are devised. Officials of the manufacturing company state that even at this cost welding is cheaper than riveting.

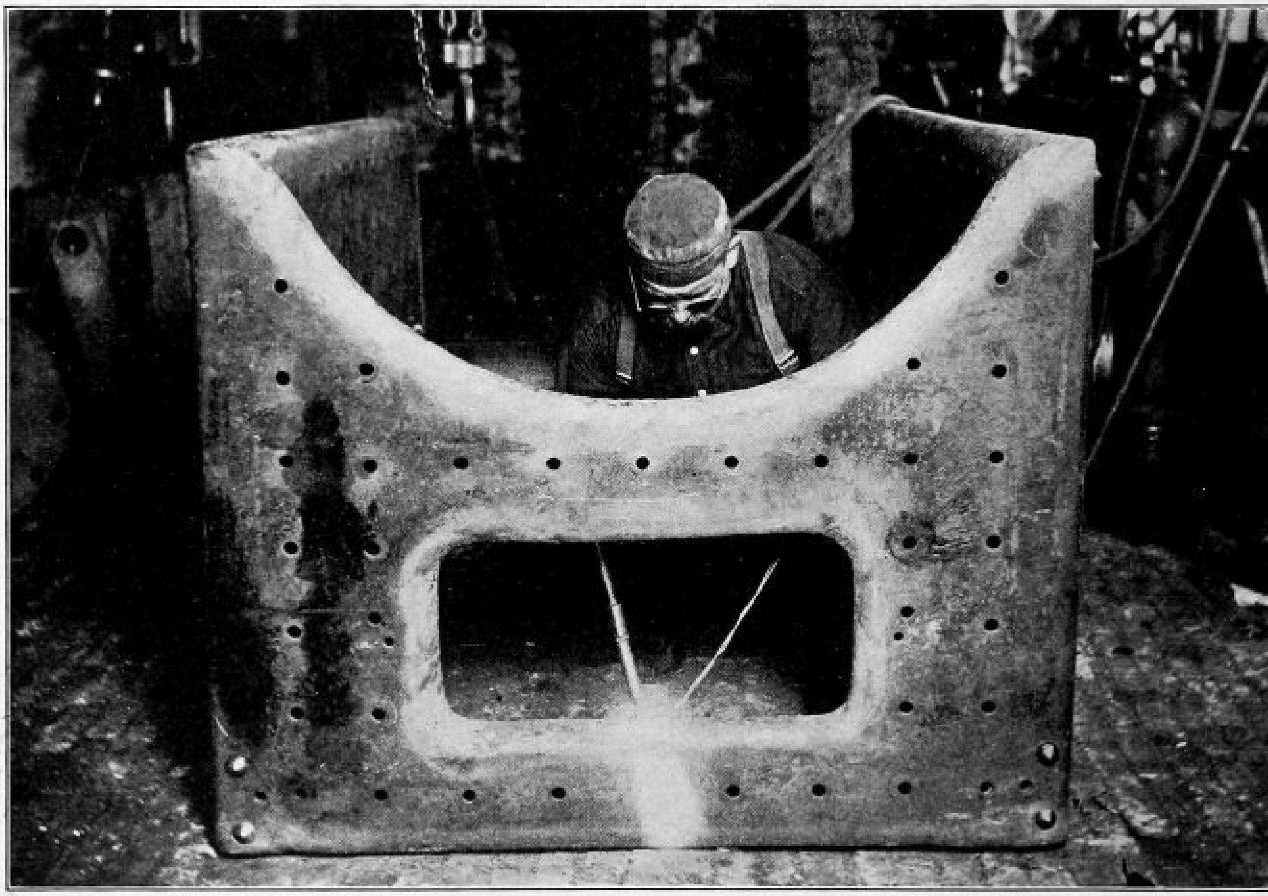


FIG. 2.—WELDED FIRE-BOX

One of the obvious advantages of the process is the fact that in welding one operator does all the work necessary, while with the former process of flanging and riveting at least three men, and for a part of the time four men, were required.

The illustration shows an operator welding various parts of the fire-box, and the method by which he alone handles the entire piece of work with blocks and falls. Twenty hours' actual time was consumed in welding this fire-box, while several hours in addition were required for handling and preparing the work. As the method is applied to subsequent manufacture, however, this extra time will, of course, be largely reduced. The riveted fire-box illustrated in Fig. 1 is of the low-pressure type, capable of standing a water pressure up to 80 pounds per square inch. One hundred and five stay-bolts were used in this box. The welded fire-box shown in Figs. 2 and 3 is of the high-pressure type, tested to 210 pounds per square inch water pressure, the sheets being supported by 210 stay-bolts, the number and size being the same as would be used in a riveted box of corresponding size and type.

Punching Large Openings in Plates

One of the most useful tools, proportionate to its cost, we ever found in a tank shop was ¾-inch square punch and die. Everyone knows the cost and time to punch an opening, say 12 inches by 18 inches, with a round punch and then chip off the points between the holes to make a straight, smooth edge. Here is the kink that saves money: Take a scrap bar or plate having one straight edge; bolt it to the plate if there are convenient holes, otherwise hold it with clamps and guide the punch along the straight edge. You will get a square punched, straight-edged opening that will not need one-twentieth the chipping the round-punched opening needs. And if you want to punch out a round opening, punch a round hole in the center, pivot through it to a bracket on the front of the punch and turn the work under the square punch. One man will do the work of three in one-third the time.—*Ryerson's Monthly Journal.*

Floor Plates

Frequently a shop will get a hurry-up order for a steel cellar door, coal hole cover, trench cover or stair platform or tread requiring a plate with a roughened surface. When time will not permit of getting a regular diamond or checkered floor plate from stock, a very good substitute can be made on a punch machine. Set the punch so that it will only penetrate the steel about one-half its thickness and use a die about ⅛ inch larger than the punch. Lay out and center punch the work the same as if holes were to be punched through the plate. For best results the punch should be about ½ inch, and the center marks spaced about 1½ inches and in straight lines either parallel to the sides of the plate or diagonally.—*Ryerson's Monthly Journal.*

Daly and Doolin Discuss Riveted Joints

BY DANNY HOGAN

"Did ye see th' discussion goin' on be th' paaper," said Daly, "about th' pitch of rivets in b'iler seams? Sure 'tis a most insthructive set of articles, an' ivery b'iler maker should be radin' up on th' subject. But th' multichude of writers splashes a pint av good ink showin' th' importance av th' proper pitch an' how to find th' efficiency av th' seam, an' all that. Thin they sthop."

"Oi read thim," replied Doolin, "an' agree wid ye that they were hoighly insthructive."

"Engineers should pay more attintion t' b'iler design, Doolin,

FIG. 3.—WELDING THE MUD-RING

for th' funny part av it all is, thim high-brow fellers niver git anny further than analyzin' th' efficiency av th' seam."

"Oi admit 'tis important," said Daly, "but 'tis like speakin' only av th' pitcher in a baseball game an' forgettin' intoirely th' other eight min. A riveted seam is a chain wid siveral links, an' 'tis important t' know th' strength av each link, wan av which, be th' way, is th' straight pitch. And, moind ye, wan must choose a diameter for th' rivet hole for a certain thickness av plate an' not run away wid th' idea that anny diameter av rivet will do fer anny thickness av plate. Nayther should th' size av th' rivet head, th' height an' diameter at th' plate, an' th' shape be disraymimbered."

"Do ye think a button head, steeple, cone or conoidal head th' sthrongest?" asked Doolin, as he filled his "T. D."

"Th' heads must hold th' plates t'gither an' sthand up for calkin' th' seam," answered Daly, as he handed Doolin a brimstone match. "Always raymimber a rivet in shear is loike a bolt in tinsion, an' th' head has t' be considered, for all th' pitch writers neglected this p'int.

"Thim chaps, Doolin, niver mintion whether th' rivet holes was punched full-soized, punched small an' reamed out in place, drilled with th' plates flat or drilled after rollin' th' plate up. Now all this constitoots a link in th' value ov a j'int whether th' ingineers think wid me or not, an' it makes th' difference in th' price of a b'iler as well. If ye are lookin' fer a cheap b'iler, just ignore th' question av makin' th' rivet holes, but if it's a good one ye want, have th' holes drilled out full-sized afther th' plate is rolled up, loike is done wid th' 16-foot Scotch marines.

"Ye may know, Doolin, that English tests show 18 percent loss in tinacity be reason ov th' punchin' ov ⅜-inch plates. Av coorse, th' higher in phosphorus th' metal, th' greater Oi believe would be th' loss. Consider, thin, this detail in findin' th' efficiency av th' rivet pitch. Say ye had a 70 percint j'int wid holes punched full size, an' say th' mill test showed carbon 9.3 percint, phosphorus 0.06 percint, an' sulphur 0.05 percint—th' b'iler made wid a lap seam, an' twinty years old at that—what efficiency would ye allow?"

Here Doolin choked slightly as some of the sulphur fumes were inhaled. When he recovered his breath, Daly said: "Goin' further down th' pike, Doolin, let's look into th' mather av whether th' seam is a true arc av th' circle. Ye know th' usual flat spot on th' sheet is along th' longitudinal seam. Now tell me, is th' finished seam truly cylindrical or not? If not, thin flexure is prisint an' to be considered.

"There's several more points. Were th' rivets driven by hand, snapped by th' gun or be th' bull? Were they overheated an' carbonized in a coal fire or properly heated in a gas or oil furnace by a lad what was onto his job? Do they fill th' hole solidly from ind to ind or only at th' inds? If not, in th' latter case, th' shear diameter is much less an' that's a factor in yer analysis of th' p'int.

"Of course, Doolin, th' bull-drove rivet is th' best, anny an' all things considered, an' for why? Th' squeeze is exerted on sthraight loines an' th' prissure is therefore concintric an' not eccintric to th' rivet. The force exerted in drivin' is that powerful it is not nadeful to heat th' rivet as hot as whin workin' be other methods, an' this avoids burned rivets.

"Again, th' best b'iler shops are now usin' only 1/32-inch clearance instid ov 1/16-inch, for th' rayson they can use a dull-red rivet wid th' bull, when th' gun would need one near white hot, an' th' latter would, ov coorse, swell in diameter. It folers, ther'fore, that in th' first case th' hole is complately filled, as there is less clearance to fill.

"Goin' back t' th' efficiency matter again, Doolin, let me obsarve that th' ink-slingers say nothin' av th' j'nt failin' be crushin' in front av th' rivet at th' edge of th' plate. 'Tis just as much a matther t' be considered as that av th' straight pitch. They say nothin' nayther av th' back or distance bechune th' rows ov rivets. But at wan glance ye can see th' importance av' analyzin' these features, as they are a link in th' chain an' an ilimint in th' question of safety.

"It's glad Oi am, Doolin, to note ye are readin' up on b'iler consthruction, an' Oi advance these few p'ints fer yer careful consideration, as th' politicians say. Whin ye land that job as examiner at th' city hall, if ye iver do, bear this dope in moind for questions t' put t' th' laads. Sure, they needs t' know all about th' subject as well as one part ov it.

"And now get onto yer job," concluded Daly, "fer Oi sint fer ye to replace some tubes in No. 4 b'iler an' Oi suppose ye'll be chargin' up th' time spint in discoorsin' av riveted seams."

"Only sthraight toime," answered Doolin, "fer 'tis day work."—*Power*.

Tests of a 1000-Horsepower 24 Tubes High Babcock & Wilcox Boiler*

BY B. N. BUMP

The boiler tested was erected as an experiment for the purpose of determining, by test and by continuous operation in the regular service of a large plant, the advantages and disadvantages of so high a boiler of the Babcock & Wilcox type. These tests were made from November, 1911, to February, 1912. They were expected to answer the following questions:

(*a*) At what rating will the highest efficiency be obtained?

(*b*) Will the superheat obtained, with the superheater located above the twenty-fourth tube, be sufficient to pay for the installation of the superheater?

(*c*) Will the last pass of the boiler be effective?

(*d*) Can the exit gas temperature be reduced very nearly to the temperature of the steam in the boiler?

(*e*) If the exit gas temperatures are close to the steam temperature, will pitting occur in the back end of the boiler, due to the sulphur content of the gas?

Boiler and Superheater

The boiler was built up of one regular 14-tube section, and above this, with a space of some 11 inches between them, was placed a 10-tube section. The headers of the 10-tube and 14-tube sections were joined by short nipples, making a 24-high header. There are twenty-one of these sections, containing a total of 504 tubes. The tubes are 4 inches in diameter and 18 feet long. There are three drums, 42 inches in diameter and 24 feet long. The water heating surface of the boiler is 10,000 square feet. Between the top tubes and the drums a Foster superheater is placed, containing 1,750 square feet of superheating surface.

The gases make three passes through the boiler. The baffles are arranged to give a gradual decrease in space through the first and second passes in the direction of flow, which tends to maintain the velocity of the gases as the temperature decreases. The gases enter the superheater from the top of the first pass, after traveling over twenty-four tubes. From the superheater they turn downward through the second pass; upward through the third pass, and then make their exit between the down-takes and through the rear wall to the stack. The spaces between the header, both front and rear, were packed with asbestos.

Stoker and Furnace

The boiler is fired by a six-retort Taylor stoker, grate area 62.465 square feet, not including any dump grate area. The ratio of boiler heating surface to grate area is 160 to 1. The ratio of boiler, plus superheater surface to grate area, is 188 to 1.

The height of the combustion chamber is about 6.5 feet, and the width of the furnace 12 feet 7 inches, which latter is greater than the width of the stoker to allow for placing a cast iron wind box on either side of the stoker. This is believed to be a new feature, tried as an experiment. Previously there had been trouble from the formation of clinker on the side walls with stokers of both the under-feed and over-feed type, owing to some coals giving a tough, sticky clinker, which is very troublesome. With the side walls against the stoker, clinker forms rapidly, and is difficult to remove. Setting back the side walls lessens clinker formation to some extent, and facilitates the removal of the clinker.

A brick ledge between the stoker and side wall is objectionable, because in time clinker will fasten to it, and it is almost impossible to get a bar between clinker and ledge. The cast iron wind boxes overcome the objections to the brick ledge by chilling the clinker so that it does not stick. A bar can always be forced between the clinker and wind box to raise the clinker. A part or all of the air from the blast fan is passed through these wind boxes on its way into the stoker. After six months of continuous service there is no sign of burning on the wind boxes.

Figs. 1 and 2 show a front and side elevation of the unit. On the side elevation the locations of the pyrometer rods and gas sampling tubes are shown. The furnace temperatures were taken through the three openings shown just under the lower tubes. The other gas temperatures were taken at positions 1 to 7, inclusive.

The walls were lined with 9 inches of firebrick, backed up by 9 inches of porous insulating brick. The outer surfaces of all walls were painted with two coats of boiler pitch to prevent any filtration of air through the brick work. Against these painted surfaces of the front and side walls, 85 percent magnesia covering 4 inches thick was placed. The magnesia was held against the brick and protected by a thin steel shell. Asbestos board was placed on the top half of the drum, then loose mineral wool was placed over the entire top of the boiler.

Test Apparatus and Data

The tests varied from 18 to 48 hours in length, although most of them were about 24 hours long. The coal was weighed in a wheelbarrow on scales tested frequently for accuracy. A small sample of coal was taken from each wheelbarrow load to make up the test sample for moisture analysis and calorific value.

The feed-water was measured in a tank of 13,000 gallons capacity. All feed-water piping was under observation, and any leaks were quickly discovered. The drips from the pump plungers were caught and returned to the feed tank. The feed-water piping being entirely independent there was no possibility of the measured water going anywhere except into the boiler. The blow-off piping was slip-blanked, and the boiler blown down only between tests. The boiler was examined for leaks at frequent intervals, and the boiler tubes were dusted every 48 hours in the intervals between tests.

Steam pressures, superheated steam temperatures and steam calorimeter temperatures were taken by recording instruments.

It was found necessary to have some suction over the fire to prevent the escape of gas into the boiler room. This suction was kept as low as possible. Gas temperatures were taken at seven different points. The seven pyrometer rods were wired to one indicating instrument, so that by the use of knife-edge switches the indication of one rod after another could be taken in quick succession.

A high-reading pyrometer was used for furnace temperatures. There was considerable trouble in keeping this pyrometer in working order, and consequently the furnace temperatures are given for only a few of the tests.

Samples of gas for analysis were taken in the first pass at the top of the fourteenth tube and before the breeching. The samples were taken through six sampling tubes placed in the space between the boiler and back wall and directly in front of the opening to the breeching. One tube was connected to a CO_2 recorder, and the other five were attached to large

* From a paper read before the American Society of Mechanical Engineers, New York.

sampling bottles, which were run continuously. The tips of the tubes were so placed that the samples taken through each represented approximately equal volumes passing to the stack.

The first nineteen tests were made with mixed coal from four different mines, all in the same region. Tests Nos. 21 to 40 were all run on coal from No. 29 mine—lighter than that used on the early tests and giving much less clinker trouble. It made a loose fuel bed and allowed more boiler capacity with less draft in the stoker. For best combined efficiency the dry coal per square foot of grate per hour is about 26 pounds,

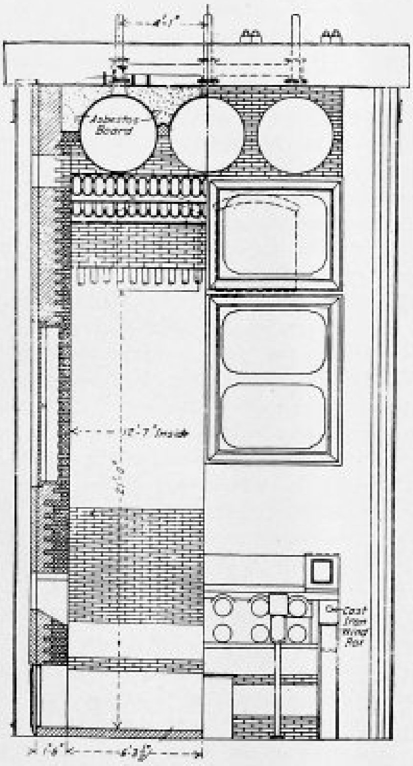


FIG. 1.—FRONT ELEVATION OF BOILER

or nearly 270 pounds per retort. The quantity of coal burned per square foot of grate per hour was increased to nearly 63 pounds, with a decrease in combined efficiency of 5.5 percent.

To determine the carbon in the refuse the total refuse was spread out upon a large floor, broken up, thoroughly mixed and quartered. The quarter sample was ground, and this ground portion was in turn quartered to get the sample for chemical analysis. The calorific values of the coals were determined by the oxygen-bomb calorimeter.

The radiation and unaccounted for losses have been calculated for those tests, for which there were ultimate analyses of the coal. The tests were made during extremely cold weather, and there was over the boiler only a temporary building affording but little protection from the elements; the boiler room temperatures were so low at times the boiler pressure gage piping and the water column blow-off piping froze. In view of these facts and the drafty condition of the boiler room the radiation and unaccounted for losses of from 5 to 7 percent are worthy of note.

The theoretical efficiency was calculated on the assumption that the only heat loss was that to the stack when the combustion was complete without excess air, and the temperature of gas leaving the boiler was equal to the temperature of the wet steam in the boiler. The efficiencies in Table 1 have been calculated for those tests for which there were ultimate analyses of the coal.

It may be possible under favorable conditions to reduce the radiation losses to 2.5 percent. With thorough mixing and a suitable type of combustion chamber the heat losses in the gas may be expected to be not more than 1.5 percent greater than the theoretical gas loss; the maximum combined efficiency which may be attained under these most favorable conditions is about 85 percent.

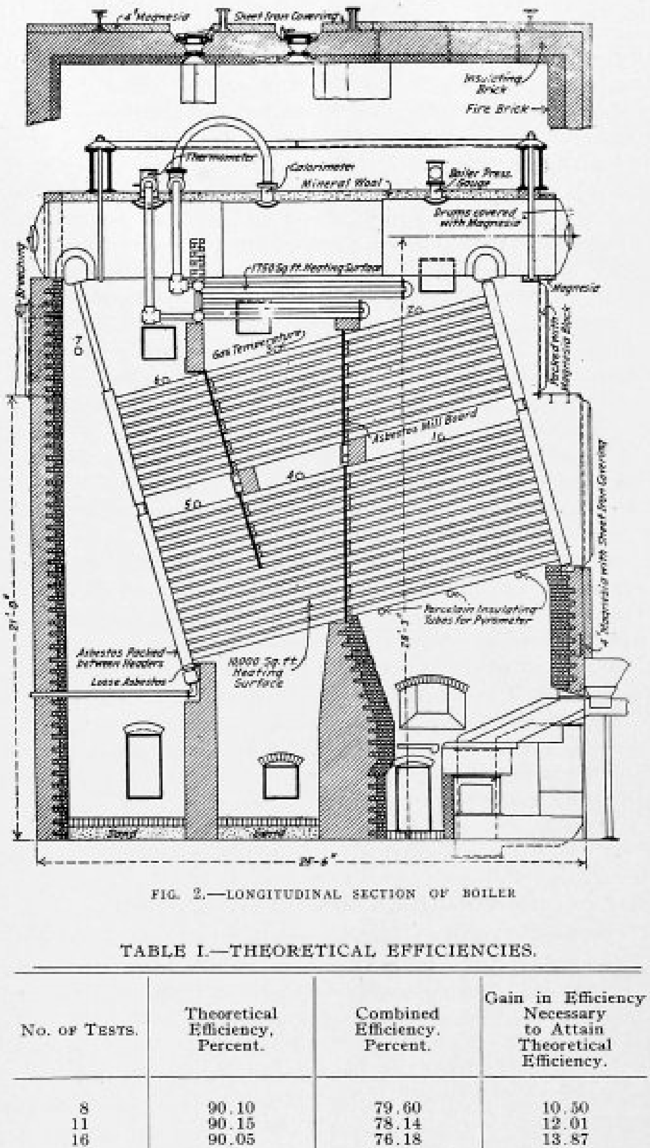


FIG. 2.—LONGITUDINAL SECTION OF BOILER

TABLE I.—THEORETICAL EFFICIENCIES.

No. of Tests.	Theoretical Efficiency, Percent.	Combined Efficiency, Percent.	Gain in Efficiency Necessary to Attain Theoretical Efficiency.
8	90.10	79.60	10.50
11	90.15	78.14	12.01
16	90.05	76.18	13.87
18	89.95	75.20	14.75
25	89.52	75.79	13.73
35	89.90	78.33	11.57
39	89.85	78.65	11.20

SUMMARY OF RESULTS

The best combined efficiencies are obtained with 56 to 66 percent of the boiler rating. The efficiencies fall off slowly as the quantity of steam generated is increased. The extreme variation in efficiency shown by the individual tests is from 75.2 to 81.3 percent.

The gain in efficiency due to the superheater seems to bear no definite relation to the amount of moisture in the steam entering the superheater. By gain in efficiency due to superheater is meant the heat absorbed by the superheater in percentage of the total heat in the coal. The superheat shows a general tendency upward with the increase in boiler rating. For 60 percent of the boiler rating the superheat is about 36 degrees F., and for 120 percent rating about 74 degrees F. At 60 percent rating the weight of steam passing through the superheat is 18,000 pounds per hour, the amount for which the superheater was built. The pressure drop through the superheater for its rated quantity of steam is 5 pounds; at 120 percent boiler rating the weight of steam passing through the superheater is double that for which the superheater was designed, and the pressure drop through superheater is 28 pounds.

At the low boiler ratings the last pass of the boiler and, in fact, the last two passes, are of very little use. The best combined efficiencies were obtained when running between 56 and 66 percent of boiler rating. At these low ratings the drop in gas temperature through the second and third passes altogether is about 20 degrees F., and the heat absorbed is very small—about 1.3 percent of the total. These two passes have 50 percent of the boiler heating surface. If the second and third passes were dropped off entirely, the loss in combined efficiency would be about 1 percent at the low rating. It is only when the boiler has reached 75 percent rating or more that the gain in economy in the last two passes is sufficient to give a reasonable return upon the investment in heating surface. While the exit gas temperatures were reduced almost to the lowest theoretical limit which can be reached without the use of an economizer, it was done at a large expenditure in heating surface.

When running at about 50 percent of boiler rating the temperature of the gases leaving the boiler is practically that of the steam in the boiler. As the capacity is increased the difference between the temperature of the gases leaving the boiler and the temperature of the steam in the boiler increases. The increase in the difference between these two temperatures seems to be approximately in the same ratio as the increase in capacity, so that for an increase from 50 to 100 percent of the boiler rating the difference in temperature between exit gases and steam increases about 50 degrees F.

An examination of the boiler after more than six months' service showed no evidence of pitting of the heating surface of the last pass, due to the sulphur content of the coal and low exit gas temperature.

Locomotive Boiler Inspection

Although little more than a year and a half has elapsed since the passing of the Boiler Inspection Act, the beneficent results of the wise measure are already apparent to the most casual observer, and a ready compliance with the details of the act is observable among all interested. Not only are the accidents arising from defective boilers less in number, but there is a spirit of unanimity in the means and methods of inspection and repair of boilers that cannot fail to still further the safety and efficiency of boilers.

A fine feature of the operation of the law is the fact that the inspectors all rank high as mechanical men of large experience. Of the fifty inspectors now engaged under the chief inspector of locomotive boilers, every one has seen service in responsible positions in relation to the construction and repair of locomotive boilers, and one of the requirements was that no one should take the examination who had been away from railroad service longer than two years. As a result it is universally admitted that the inspectors are high-class representative mechanical men.

It will be remembered that the act was the outgrowth of a resolution adopted at the Los Angeles convention of the Brotherhood of Locomotive Engineers in 1904, and although it took seven years to bring about an enactment it was no fault of the Grand Chief Engineer, or those associated with him in this good work, but the delay was caused by the fact that there is such an enormous mass of bills submitted to Congress that only a small fraction of them ever reach even the smallest amount of consideration, so that in comparison with other measures the Boiler Inspection Act came into operation with a degree of rapidity beyond the expectation of those familiar with Congressional legislative methods.

The sections of the act are being constantly amended and added to, and it should be the duty of every one in any way connected with the cleaning and repairing as well as with the inspection of boilers to become familiar with the provisions of the measure. It is the best expression of the best thoughts of the most experienced men on the subject, and the members of the Inter-State Commerce Commission gladly welcome any suggestions tooking toward the perfecting of the measure. Last month two important amendments were made on rules 29 and 35, so that the former now reads that "Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gage. The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested." The latter amendment refers to the setting of safety valves, and states that "Safety valves shall be set to pop at pressures not exceeding 6 pounds above the working steam pressure. When setting safety valves two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 pounds they shall be removed from the boiler, tested, and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock."

These two amendments become effective on and after Jan. 1, 1913, and while rule 29 does not seem to convey much that is not in general practice, it emphasizes and makes clear the use of a siphon pipe, and also its connection directly to the boiler instead of being connected to chamber or header, as is sometimes the case. Rule 35 is a distinct and new departure from common practice, and while at the first glance it may seem superfluous to have two gages while adjusting the safety valves it is obviously in the line of safety. The writer recalls numerous occasions when adjusting safety valves that there was a tendency on the part of the assistant in the locomotive cab who had the opportunity of observing the gage and calling out the record to drop 100, and instead of stating fully 150 or 160, as the case may be, would lazily call 50 or 60, assured that the "hundred" would be understood. Of course, any mechanic of experience would know the variation on the pressure of the wrench, as well as the blast of the escaping steam on pressures of 50 or 150, but possibly something of this kind occurred in the appalling disaster at San Antonio, Tex., which resulted in such a disastrous explosion, and when the safety valves were found to be screwed down as far as the thread of the studs would allow, and probably a pressure between 300 and 500 pounds had accumulated in the boiler on account of the carelessness or lazy stupidity of some unskilled worker. The pressure of a gage before the eyes of those who may be adjusting the safety valves is a step in the right direction, and will be soon fully appreciated by all who have at heart perfection in detail looking towards increased safety in operation.

A recent address, delivered before the members of the Southern and Southwestern Railway Club at Atlanta, Ga., by Mr. John F. Ensign, United States Chief Boiler Inspector, is perhaps the most lucid exposition yet given in the subject of locomotive boiler inspection, and a series of questions to which Mr. Ensign made copious replies showed how thoroughly he had conned the subject of which he has taken pains to become the highest living authority, and a copy of his excellent lecture, if it were possible, should be in the hands of thousands of mechanical railway men whose work is largely guided by a thorough knowledge of the enactment.

Want of space prevents us from taking up more of the details of the rules so far in operation at present, but we shall refer to the matter from time to time, and especially in regard to any new clauses that may be added, to the end that our readers may be kept informed of these changes.—*Railway and Locomotive Engineering.*

The Design of Locomotive Fire-Boxes*

BY J. D. TWINBERROW

When a record is kept of the incipient failures of the component parts of locomotive fire-boxes, it will be found that for any given design there is regularity as regards the positions where broken stays and cracks in the tube and other plates first appear.

A detailed examination of the design will usually reveal the presence of high stresses under the statical load of the working pressure. These stresses are not a necessary corollary of the mechanical problem, though they are present in the majority of modern designs; their persistence may be attributed to general adhesion to faulty precedent, and to insufficiency of technical supervision over the detail of drawing office procedure.

No railway can afford to be indifferent to the cost of fire-box repairs. The secondary statical stresses may be eliminated with but slight modification of detail, and the stresses due to the movement of expansion and contraction may be kept to a low value by ensuring due relation between the diameter and the length of stays, and by other provisions of known nature. The net result will be so great an addition to the useful life that no further apology is needed for continued reference to the matter.

Fig. 1.

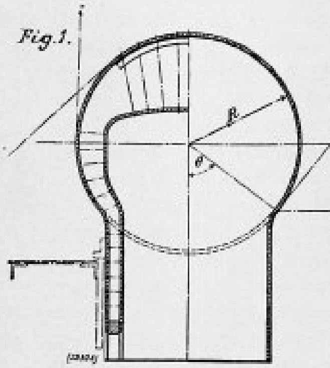


Fig. 2.

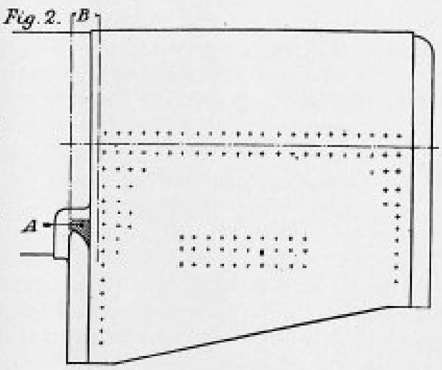


Fig. 3.

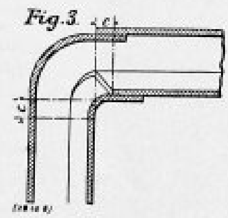
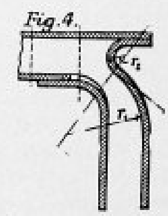


Fig. 4.



The annexed Fig. 1 represents a cross-section of a typical fire-box; the section plane of one-half is at the middle of the length, and of the other half immediately in front of the tube plate. The roof is assumed to be supported by any system of staying which transfers the load wholly or in part to the crown of the shell plate. Fig. 2 represents a side elevation of the box, the positions of the stays most liable to fracture being indicated thereon. These are also the positions in which flexible stay-bolts would naturally be fitted in order to mitigate the trouble.

The throat plate is flanged back to meet the shell, but the radius of the flange is obviously not constant; it must diminish to zero near the upper extremity, where there is necessarily an area of plating shown at *A*, in Fig. 2, which is flat, or which partakes of the reversed curvature employed to connect the curve of the barrel to the flat side. The pressure on this area requires support; it is connected across to the opposite side by the indirect system, comprising, on the one hand, the end of the cylindrical barrel, and, on the other, the tie built up of the adjacent stays and the tube plate with local attachment to the fire-box sides. In the case of the Belpaire type of box, the area at each side is doubled, and there is a third similar area at the crown, where the flat roof merges into the barrel. In some designs provision is made for balancing these pressures directly, thus avoiding the bending moments on the stays and tube plate. The curve of the throat plate flange may alternatively be merged into that of the barrel along a definite groined line of intersection. The resultant tensions at the meeting line will vary with the dimensions of the flange and with the relation of the width over the sides of the shell to the diameter of the barrel. When the cross-section exhibits a marked degree of "waisting-in" in order that the lower part of the box may fit between narrow frames, the local load on the stays and on the tube plate is increased. Referring to Fig. 2, the length *B*, comprised between the face of the throat plate and the range of the first row of stays, maintains, as regards its upper part, the normal shape of the barrel, the tension on the strip being $p \times B \times R$; the downward pressure on the projected plan of the throat plate, on the forward part of the foundation ring, etc., balances the vertical component of the tangential pressure, and leaves a horizontal pull, the intensity of which is equal to $p\,B\,R\cos\theta$, and which is balanced by the equal pull on the opposite side, the connection being effected through the neighboring stays, the tube plate and its flange, which are all thereby subjected to heavy bending moments.

In order that the stays adjacent to each vertical corner may be subject to simple tension only, and that the flanges of the plates may be relieved of bending moments, it is essential that the curve of the flange of the shell plate should be concentric with that of the inner box. This condition does not always obtain at the foundation ring, and when the width of the water spaces is increased from the foundation upwards it is not usual to find the curvature of the corners modified to suit. Fig. 3 represents a horizontal section taken at some distance above the foundation ring at a point where the width of the water spaces has been increased by 50 percent over the width existing at the bottom. The plates are flanged to curves of constant radius; they are concentric at the foundation ring, but the centers are separated by a distance c at the plane of the section. When the vertical pitch of the stays is 4 inches, the excess area of flat plate in the outer shell is $4\,c$, and the load $4\,p\,c$ is transmitted to each opposite corner through the indirect ties formed of the adjacent stay and the flanges of the plates.

* From *Engineering.*

It is sometimes found convenient to form the back plate with a reversed flange, as shown in Fig. 4, in order that the rivets may be closed after the inner box has been fitted to place. This detail requires care in order that the bending moments on the plates may be kept within reasonable limits. If there were no bending moments on the curved flange, the effect of the internal pressure would be to produce a load equal to p $(r_1 + r_2)$ per inch of depth of plate acting along the common tangent to both curves. The point of contrary flexures on the flange will depend on the relative stiffness of the back and of the shell plates; with ordinary proportions it would lie about midway between the tangent point and the pitch line of the rivets. The contary flexure of the side plate will be thrown forward approximately into line with the normal through the center of radius of the corner of the inner box; thus the first row of stays will not necessarily be subject to bending stresses. In practice, however, this distribution would entail excessively great bending stresses at the junction of the side and back plates; the elastic deformations tend to an equalization of the stresses, the pressure on the flange producing a certain amount of bending stress throughout the curve, reducing the intensity of the stress at the vertical seam and imposing an appreciable amount of bending moment upon the stays and the plates to which they are attached.

The breakage of stays in the neighborhood of the expansion brackets results from the working of the frames under the influence of the lateral forces transmitted through the axle boxes. In the case of high-speed locomotives these forces may amount to about 8 tons per axle. The modern fashion of dispension with thrust collars on the axles brings the whole of this load to bear on the frame at one side in place of dividing it equally between the frames.

In the ordinary type of six-wheeled engines the frames were stiffened laterally by means of the continuous foot-plate, as indicated in Fig. 1. The moment of inertia about a vertical axis of the frame complete with the foot-plate and its supporting angles was equivalent to about 2,500 inch-units. In many modern engines the distance between the frame cross-stays has been increased to accommodate the greater length of fire-box, while the attachment of the foot-plate has been cut away to clear coupled wheels and for other reasons, so that the lateral stiffness is little more than that of the unsupported frame plate, and the deflections in working are relatively enormous. They are perceptible on the foot-plate in the character of the riding with many classes of ten-wheeled, or "Atlantic" engines. There is evidence of heavy straining on the attachment of the expansion angle-iron, and the neighboring water-space stays are seriously distressed in consequence.

It is not practicable to support the roof of a long box by transferring the entire load to the top of the tube and back plates. When the downward pressure is wholly or in part balanced by means of radial, direct, or sling stays connected to the crown plate, it is desirable to take care of the horizontal components of the radial pressures by means of transverse stays or by continuing the crown stiffeners right round the shoulders down to the range of the upper row of water-space stays. In the absence of such support the internal pressure produces a tension in the shell plate equal to $p \times R$ per inch run, the resultants of which are indicated by the arrows shown on the cross-section in Fig. 1. In producing equilibrium these stresses naturally induce bending moments on the attachments of the crown plate, and on the upper rows of water-space stays. In practice the actual stress in the unsupported shoulder of the shell plate may be expected to consist of cross-bending in addition to pure tension, with consequent modification of the line of action of the resultant pressures.

The exact calculation of the intensity of stress for any given conditions is a matter of some difficulty, but it is probable that the bending moments on the rows of stays adjacent to the corner and the compression acting across the radius of the roof of the inner box, when the arrangement is as indicated by Fig. 1, would involve ultimate fiber stresses of higher degree than the elastic limit of the materials employed. The resulting deformations prolong the period of effective service by reason of the more remote stays taking up an increasing share of duty.

When the slings of long girder stays are attached to short crown sheet angles it is found that the rivets in the latter must largely exceed the number required for direct support of the roof load, otherwise they will not suffice for the duty of uniting the angles and the crown sheet as a composite brace to tie the shoulders.

In American practice all modern boilers are made with wide fire-boxes entirely clear of the framing and of the wheels, so that every stay is accessible for examination or renewal without entailing expense in dismounting. The boilers are subject to continuous inspection under State regulations, which usually prescribe that a signed copy of the inspector's periodical reports shall be posted in the cab. Any stay found to be broken must be cut out and replaced without delay. It may be observed also that in the State of New York every smoke-box of the short type must be opened out and examined at the end of every trip; extended boxes fitted with the normal pattern of deflector plate and inclined spark arresters are opened once a week.

The fire-box shells are almost invariably of the round-topped variety fitted with direct radial stays. The width of the water spaces is increased from the foundation ring upwards without any special provision for counteracting the influence of the inequality of the areas of the flat plating to be supported. The radial stays may be assumed to take the whole of the load on the crown of the inner box; they also balance the whole of the internal pressure along the center line of the shell, and a diminishing proportion thereof from the center round to the shoulders. The unbalanced portions of the internal pressures act with increasing intensity at the head of each row of stays, as the angle of inclination of the latter deviates more and more from the normal as the sides of the box are approached; they produce bending moments which acquire their maximum degree of intensity at the level of the top of the water space. As the upper water space stays are shorter than the radial stays next above them, they are more rapidly fatigued by the consequent deflections. It will be conceded that, so long as the general design remains unaltered, American engineers are following a logical procedure in fitting flexible stay-bolts along the upper courses and adjacently to each of the vertical corners of the water spaces.

When a force tending to deform the cross-section acts upon the structure composed of the inner and outer plates and their connecting rigid stays, it produces bending moments which are of maximum intensity where the ends of the stays are fixed in the plates with points of contrary flexure in the middle of each stay and in the plates midway between the rows of stays. If, however, the upper stay is provided with a ball-and-socket bearing at one end, that connection cannot be subject to bending; there is no contrary flexure in the body of the stay, and for a like intensity of stress at the fixed end the reflection of the free end will be doubled. The greater elasticity of the flexible stay throws more of the duty onto the rigid stay next beneath. By the employment of several tiers of flexible stays the resisting power of the stays below the danger zone may be brought into play with a concomitant reduction in the intensity of stress in those positions where reason and practice reveal the existence of a liability to fracture.

In the year 1910 the Canadian Pacific Railway Company introduced a modified form of construction to enable the crown of the shell to receive the roof load from the radial stays without involving stresses due to cross-bending. T-bars were riveted around the internal surface, braced with transverse ties above the level of the top of the fire-box. At the same period other builders in North America had adopted, more or less tentatively, the practice of fitting flexible stay-bolts along the upper courses at each side and down each of the four corners. The results obtained after two or three years' actual service will effectively indicate the value of these provisions for reducing cost of maintenance.

Conclusion

The wasting action of the fire and the fatigue due to movements of expansion necessarily limit the useful life of fire-boxes; but the occurrence of broken stays and the formation of cracks in the tube and other plates are usually hastened by characteristics of the design.

The cost of repairs and renewal of fire-boxes constitute a large percentage of the total expenditure on locomotive maintenance.

The direct outlay on labor and materials is accompanied by the loss of effective motor power, due to the withdrawal of engines from service for boiler repairs.

That absolute failures are of rare occurrence is a high tribute to the class of workmanship and materials employed, and to the efficiency of the methods of inspection and supervision in vogue.

A High Speed German Compound Locomotive with Schmidt Superheater

BY FRANK C. PERKINS

The four-cylinder express locomotive shown in the accompanying illustration, Fig. 1, as constructed at Wurttenberg, is equipped with a Schmidt superheater, the boiler installation being indicated by the accompanying drawings, Figs. 2 and 3. This engine was built by the Maschinenfabrik Esslingen, in Esslingen, and the design of this locomotive is most unique.

The high-pressure cylinder measures 16.54 inches in diameter and the low-pressure cylinder 24.41 inches, with a stroke of 24.08 inches. The driving wheel base is 70.87 inches, and the weight of the locomotive, empty, is 75.9 tons, and when ready for service, with water and fuel, its weight is 85 tons.

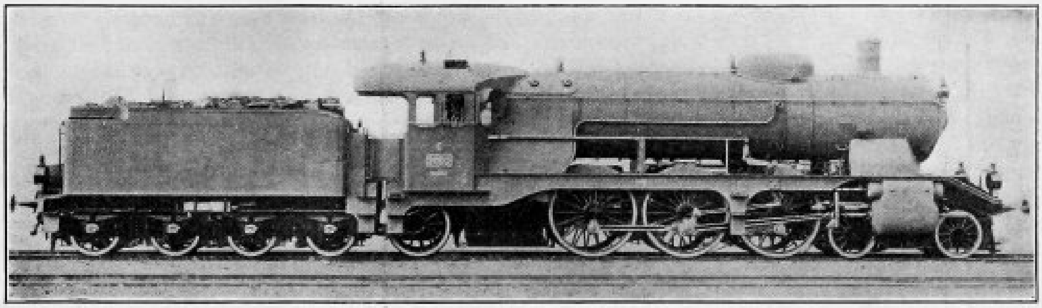


FIG. 1

The boiler was designed for a working steam pressure of 220½ pounds per square inch, and is provided with a superheater, having a total heating surface of 570 square feet, the entire heating surface of the boiler being 2,820 square feet, of which 2,240 square feet represent the heating surface of the tubes, the grate area being 42.5 square feet.

This four-cylinder compound locomotive was designed for operating on the Kgl. Wurttenbergischen Staatseisenbahnen. It has a total wheel base for locomotive and tender of 51.2 feet, the total length being 65.75 feet. It is stated that the steam consumption is 17.3 pounds per horsepower with a speed of 60 miles per hour, hauling a train of 373 tons, the total indicated horsepower being 1,780.

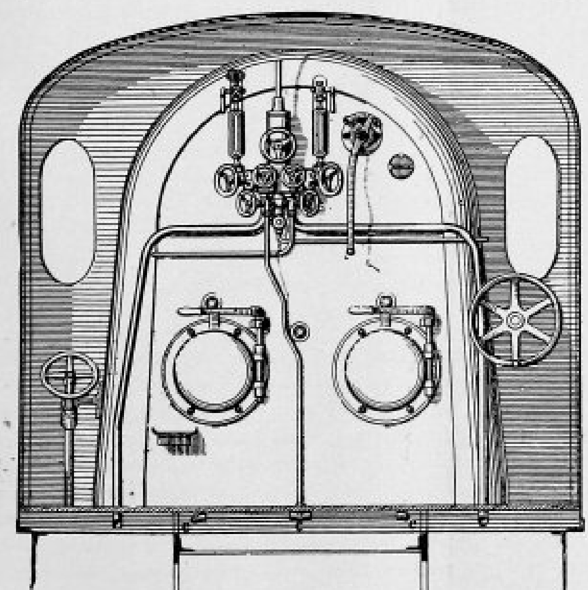


FIG. 2

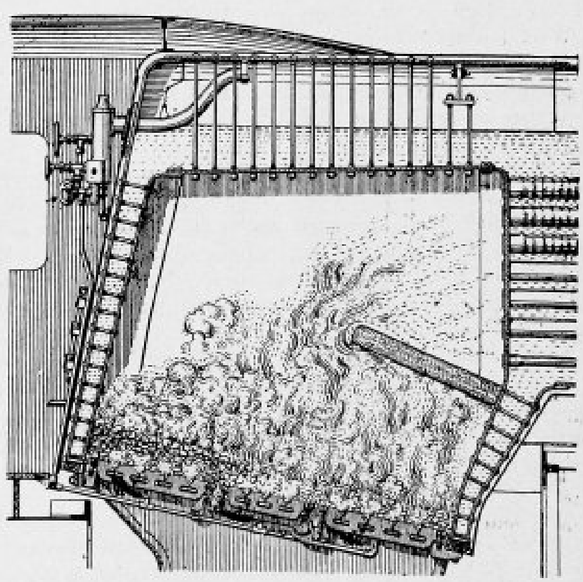


FIG. 3

Boiler Shop Geometry—John Gets Some More Pointers

BY JAMES F. HOBART, M. E.

"What are you doing, John? The shop might burn down and you not know it—you are so busy over that job."

"I am trying to divide this angle, Mr. Hobart. I want to divide it into three equal parts. I can divide it into two parts, but three bothers me."

"How do you divide it into two parts, John? You show me this time."

"Why, I draw the two lines *B* and *C*, Fig. 1, which form the angle at *A*. Then, with the dividers open at any convenient distance, I cut across *B* and *C*, then put one leg of the dividers at *B* and draw the arc at *D*, then change the divider to *C* and draw another arc at *D*, then I draw in the dotted line *A D*, and that divides the angle *A* into two equal parts.

"Now I want to divide the piece shown by Fig. 2 into three equal pieces, so when I cut the sheet the three pieces will be equal, each of the angles *a* will be one-third of the large angle *A*, so that it divides the sheet into three pieces, *C D*, *D E* and *E B*—each equal in width but a little different in length."

"Well, John, you bisected the angle all right. The scheme shown by Fig. 1 is the correct method of working out that problem, but let me tell you something. Don't waste time trying to trisect the angle as shown by Fig. 2. The mathematical sharps have not done it yet. Here is a case where a geometrical stunt won't work. Just draw the arc *a*, *a*, *a*; step it off with the dividers very carefully into three equal chords, then draw the lines *A D* and *A E* and you have the piece *A B C* divided into three equal pieces as far as their angles are concerned.

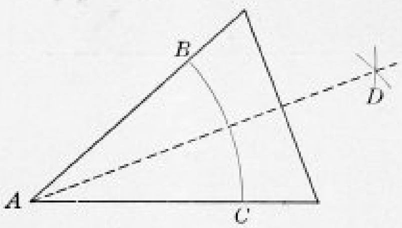


FIG. 1.—BISECTING AN ANGLE

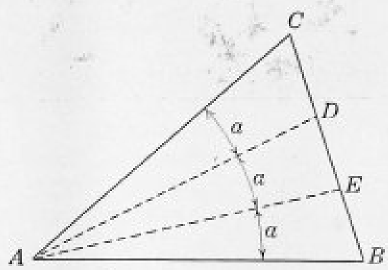


FIG. 2.—TRISECTING AN ANGLE

"There is a chap in Hanford, Cal., who claims to have trisected angles. He offers his method for sale for a dollar, and says he will give $20.00 to any man who proves he is wrong."

"Well, I would like to know how to trisect angles, but the old man won't pay me a dollar for doing it, so I think I won't invest just yet. But say, Mr. Hobart, is not there some way of picking up angles, so I can lay them out without a protractor?"

"Yes, John, you can do the stunt with a steel square same as the carpenters use. On page 275 of the September BOILER MAKER a method of laying off angles is described, directions being given for laying out 30 degrees, also 23 degrees. We can lay both off in the same way, if we choose, so just look up that copy of THE BOILER MAKER and see if that method will answer your purpose."

"I have read that, Mr. Hobart, and it works all right for 30 degrees, but I want to know how to take out any angle that comes along. It looks a little out of place to be using a little dinky 3-inch protractor on an 18-foot sheet of boiler steel. So, if there is a way more like a shop method, I wish you would put me next to it."

"All right, John, if you have a table of natural sines you can lay off all angles with the assistance of the steel square. If you don't feel like paying four or five dollars for a copy of Kent or Templeton, then buy one of Jones & Laughlin Steel Company's little books. The title is 'Useful Information for Business Men, Mechanics and Engineers.' The title is a great deal bigger than the book, which is only 3¼ inches by 2 inches by ½ inch, and has 493 pages of dope. It is a mighty handy little book in the boiler shop. The address of the firm is Pittsburg, Pa."

"Is it big enough to be any good, Mr. Hobart? I don't want a book if it is N. G."

"Yes, John, it is good. Not as good as a large data book, but you will get $12.00 more a week as soon as you know one-tenth of what is in that little book."

"How will I use it after I get it? Will I have to get other things—drawing instruments, scale and triangles?"

"No, John, but you ought to have them, anyway, and you ought to be able to 'fake' up some kind of a sketch or drawing. The more you get wise to such things the quicker your pay envelope will get fatter. But all you need except the table of sines in the book is a common steel square as used by carpenters."

"Fig. 3 is about the same as was given in the September BOILER MAKER. It shows how to lay off 30 to 60 degrees. Now, John, here is a pocketbook and there is a table of sines. Look up the sine and cosine of 30 degrees and tell me what they are."

"Well, here it is: opposite 30 degrees I find 5,000, but I don't see any cosine."

"Five is right, John; but instead of being 5,000 it is .5000."

"Why, I should call that 5/10!"

"That is what it is, John, but all the sines in the book are carried out to four figures."

"Say, Mr. Hobart, what is a sine, anyway? If you can tell me so I will understand it, I will be very glad. I have read what the book says, but I don't quite understand it."

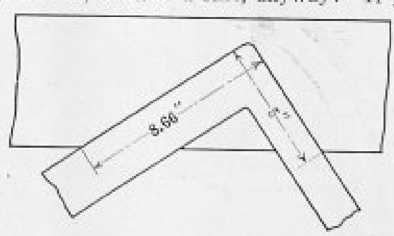


FIG. 3.—LAYING OFF ANGLES

"Yes, John, I will tell you in a very few words. Just draw a piece of a circle, starting at *A*, Fig. 4, opening the dividers just 1 inch or 1 foot or 10 inches, whatever you have a mind to. Perhaps you had better take 10 inches. Then, with one leg of the dividers at *A* and the other at *B*, draw a piece of a circle up towards *C*. Now draw one line from *A* to the curve *D C*, no matter where it touches. Now, John, draw a line from point *D* where the line just made touches the curve, and draw the new line just down through *A B*, crossing it square with the line."

"Yes, Mr. Hobart, here it is."

"Well, John, you have an angle at *A*, haven't you?"

"Yes, sir, the lines *A D* and *A B* make an angle."

"All right, John; the line *A B* is 10 inches long, is it not?"

"Yes, sir, sure; and the line *A D* is 10 inches long, too!"

"That's right, John; you are catching on. Now then draw a line from *D* down to *E* on line *A B*, and it is the sine of the angle at *A*. That is, it measures the angle. If we draw

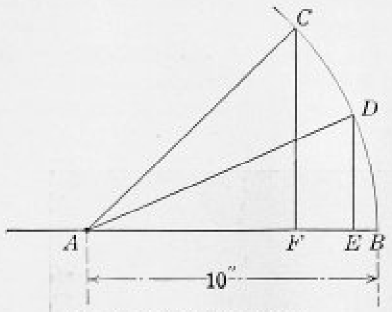


FIG. 4.—SINES AND COSINES

another line straight up to *C* and drop another line down to *A B* at *F*, then we have another sine much longer than the sine *D E*."

"Gee! I see it now; the bigger the angle the longer is the sine."

"Sure, John, that's just it."

"And the circle radius is drawn one unit long so that all the sines must read in fractions that way?"

"That's just the case exactly, John."

"Then if I take a sine out of the table, that's the measure for an angle the side of which is 1 inch long?"

"Yes, John, that's the case; 1 inch, 1 foot, 1 meter, or just one."

"Then if I want to find the angle to some other figure the unit of which is 14 inches long, I have to divide that down until it comes out just 10."

"Sure, John, you divide the 14 by 1 4/10; that will give you a radius of 1 or 10 to work with."

"Oh! I see it now. The sine business is not so hard after all, is it?"

"Not when you understand it, John. There is nothing hard which is thoroughly understood. It is only hard before you understand the matter thoroughly."

"But say, Mr. Hobart, how about the cosine business? I don't see any cosines in the table. Can you tell me what they are?"

"Sure, John; the cosine of the angle *B A D*, Fig. 4, is the distance from *A* to *E*. That is, from where the sine hits the radius to the apex of the angle. The cosine of the bigger angle *C A F* is equal to *A F*. So you see, John, as the sines get bigger and bigger as the angle increases the cosine gets smaller and smaller."

"Say, that is so, isn't it? Crackey! When the angle is nothing the sine will be nothing."

"Sure, John, that is right."

"And then won't the cosine be 1?"

"Sure thing, John."

"And say, Mr. Hobart, with an angle of 45 degrees ain't the sine and cosine equal?"

"Every time, John. You lay off two sides of a square; those are the sines and cosines; you draw the diagonal, that's the radius, and there you are; you have a square or 90 degrees."

"Say, I am mighty glad to get in on that sine business. Then when we get upon the bigger angles the cosine gets pretty small, doesn't it?"

"Sure, John."

"And when we get up to 90 degrees the sine is 1, and the cosine is nothing?"

"That's the case exactly, John, and you can keep right on into the other quadrant if you want to, and the sine and cosine will increase and diminish just as they did from *B* up to *C*. Now, John, let me tell you one more thing. You notice that for 45 degrees the sine and cosine are equal?"

"Yes, sir, that's so."

"Now, if we take any angle from 90 the sine of the angle will be the cosine of the angle remaining from 90. Say, John, the book people say that subtracting an angle from 90 degrees gives the complement of the angle. Just take the 30-degree angle, subtract it from 90, and you have 60 degrees remaining as the complement of 30 degrees. Now, John, the sine of 30 degrees is the cosine of 60, and the cosine of 60 degrees will be the sine of 30 degrees."

"That's the way you work, is it?" I sure couldn't find any cosine business in that table."

"No, John, in Jones & Laughlin they do not give cosines; so you have to look up the complement of the angle and call its sine the cosine of the figure. Now come back to Fig. 3. We have found the sine to be 5. We will call it 5 inches. Measure that off on the square as shown in Fig. 3. Now look for the sine of 60 degrees. What did you find it?"

"8,660, Mr. Hobart. Shall I call it 8.66 inches?"

"Yes, John, that is right. Mark that off on the other leg of the square. Lay it on the work as shown by Fig. 3. Now mark along both edges of the square and you have angles of 30 and 60 degrees, respectively—the smaller side always opposite the smaller angle and the bigger one opposite the larger angle."

"Say, can I work any angle this way?"

"Yes, John, any angle you can think of, and the accuracy of your work depends on how close you make your measurements on the square."

"Wonder if that's where they got that old saying, 'On the square'?"

"Shouldn't wonder. It means that what you say or do is measured in both directions, also 'square up' from bottom to top. Pretty good thing, John, to be always 'on the square' and to make your personal measurements close, too. There

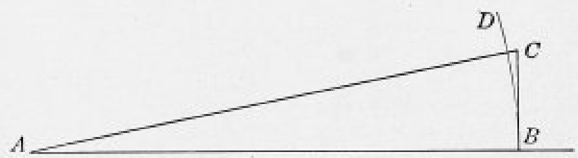


FIG. 5.—JOHN TANGLES UP IN TANGENTS

was never anything gained yet by 'scamping' in either work or actions. You have simply got to be 'on the square' before you can progress, either in your work here or hereafter."

"I'm finding that out, Mr. Hobart. Every time something wrong gets into a job it leads to a whole lot of other errors, and sometimes it's a barrel of trouble to hunt out and correct the things which are wrong. It's sure pretty hard to keep things straight, but it's a whole lot harder to straighten them out after once letting in errors and things which I know are not quite right."

"That's true, John. Follow that path, and not only realize it but *do* it, and your progression will be rapid, both materially and spiritually."

"Mr. Hobart, here is where that sine business won't work. I was trying to get the length of a brace and found the run to be from *A* to *B* (Fig. 5), the drop from *B* to *D*, 36 inches and 6 inches. Now, how can I find the distance *A D*, which is the length of brace? I tried the sine and cosine way, but it didn't seem to work out right."

"No wonder it didn't work out right, John. You are not working with sines; not at all in this case. You have got tangled up in tangents, and they are an altogether different brand from what sines are."

"Say, Mr. Hobart, what's the difference, anyway? In Fig. 5 isn't *B C* the sine of angle *A*, same as in the other diagrams?"

"Not by a good deal, Master John; it won't do to work from the longest side, as you have at *A B*. In working sines you take the long side as radius, and the angle to work with in finding the shorter sides. But here you have the shorter sides given, and you are working to find the longer side, or "hypoteneuse," as it is called, and you can find the angle at the same time, if you care for it."

"O, ho! sort of a backwards working of the sine business, isn't it? One works right in the opposite direction to what the other does. Say, Mr. Hobart, that ought to be right handy sometimes. How do you work that bag of tricks?"

"Just about the same as you did the sines, John, only look up the distance *B C* in a table of tangents instead of in the sine table. There is a whole raft of co-tangents, too, same as with sines and cosines. But we won't have to trouble them this trip. The tangent *B C* and radius *A B* are what you have got to work with, and you reduce the radius to 1, or 10, same as with sines, then go ahead in the same manner to find length of *A C*, which is called a 'secant,' and is in the table with sines and tangents in the larger data books—and that is one reason why you want one of those books."

"But, Mr. Hobart, how am I going to tell whether I get sines or tangents to work with. They look pretty much alike in Fig. 4 and Fig. 5. Isn't there some mark to tell them apart with?"

"Sure, John, dead sure! The sines and cosines are all just inside the circle you strike to connect the points, while the tangents and co-tangents are just outside the circle. Then, John, juggle the lines around, calling that one 'radius' which will bring the vertical line inside the circle, and then you have sines to work with instead of tangents, which is a whole lot handier in some cases."

"Oh, I see! Instead of calling *A B*, Fig. 5, the radius and working it down to 1, I take *A C* as radius and reduce that to 1?"

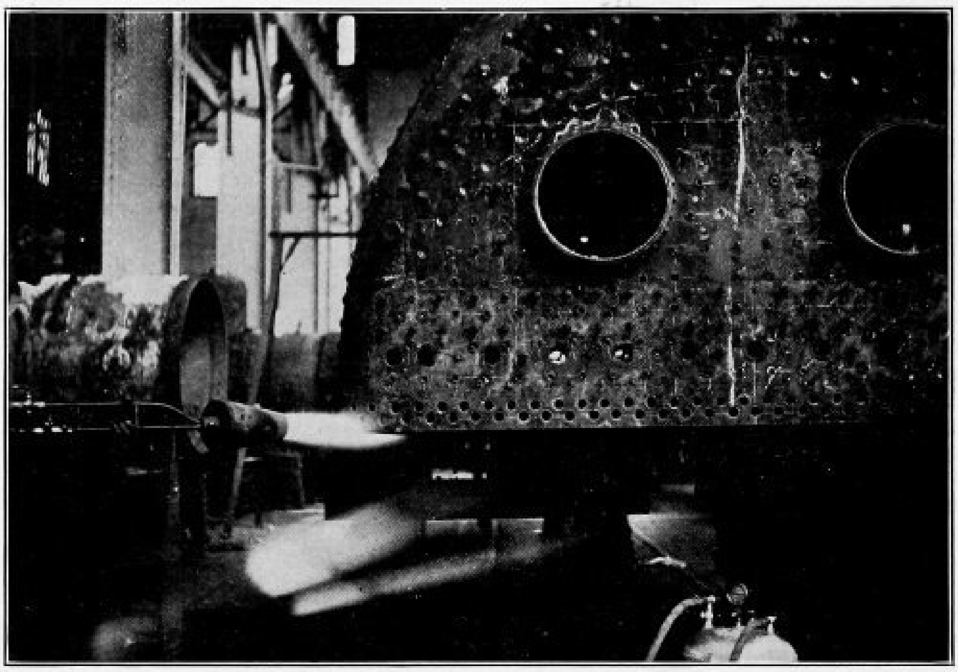
"Sure, John. That's is just the difference between a sine and a tangent. The first is an inside man, the tangent is a 'rank outsider.'"

"I'm getting onto it a little now. Gee! I didn't know geometry was half so interesting or I'd have been after it long ago!"

"That's what the chap said after he got married, John. But hold up! This isn't geometry! This is trigonometry that we are working now, but it depends right square upon geometry and is tarred with the same brush, so we won't look to see what breed it is, as long as it helps us out with our work."

"Say, Mr. Hobart, be over again soon?"

"Sure, but where are the questions you and Bill were going to send in?"



AN OIL BURNER IN OPERATION IN BOILER REPAIR WORK

Repairing a Boiler Fire-Box with a Hydro-Carbon Burner

The method employed in heating a boiler fire-box with a modern hydro-carbon burner is shown in the accompanying illustration. It is stated that the construction of this apparatus is very simple, and in operation is absolutely reliable, while it can be handled safely by any workman.

It may be stated that there is a great quantity of refuse commercially known as "hydro-carbon" in the process of the manufacture of "Pintsch" gas. The quantity of gas that can be obtained from a given quantity of oil depends upon the composition of the oil and the temperature at which it is distilled. The latter variation affects also the quality of the gas.

It is maintained that 1 gallon of the oil will produce approximately 80 cubic feet of gas, and in each 1,000 cubic feet of gas there is contained approximately 5 gallons of tar and 1 gallon of "hydro-carbon" oil.

An important feature of this burner is that it can be changed with a slight alteration so that any liquid fuel can be successfully used with same. This machine is available for constructing and repairing steel tanks, straightening and welding engine frames. It can also be employed successfully for preheating in connection with thermit welding, constructing and repairing the boiler, as noted in the illustration, as well as for brazing and various other heating operations.

An Ideal Boiler Tube Department*

BY L. R. POMEROY

An extensive investigation of the methods employed in the repairing of locomotive boiler tubes by the various railway shops reveals the fact that in many cases the same attention has not been given to standardizing the tube repair operations that has been devoted to providing modern tools and efficient organization for machine shop operations.

In shops where but ten to fifteen locomotives per month are given heavy repairs, the number of tubes required to be handled daily is so small that the ordinary box flue-rattler, more or less antique in pattern, is sufficient to keep up with the demand, but it is by no means efficient and gives a high labor cost per tube cleaned. When the shop is of a size that requires the handling of 400 or more tubes a day, the question of giving the tube department adequate consideration is of decided importance. This number of tubes is beyond the capacity of the home-made box-rattlers or cleaners under average water conditions.

It is quite a surprise to find, even in the larger shops, how little effort has been made towards providing the best apparatus suited to the purposes and arranging the sequence of operations so as to reduce the cost for each tube to an economical or rational figure. Data on costs show that the extreme usually varies from 5 to 8 cents per tube, from the engine in the erecting shop through the tube department and back to the engine. With modern apparatus and some attention given to the arrangement of the tools, these costs need not run over 3 cents a tube where 400 or 500 tubes are handled daily. In fact, one reputable concern manufacturing well-

* From *The American Engineer.*

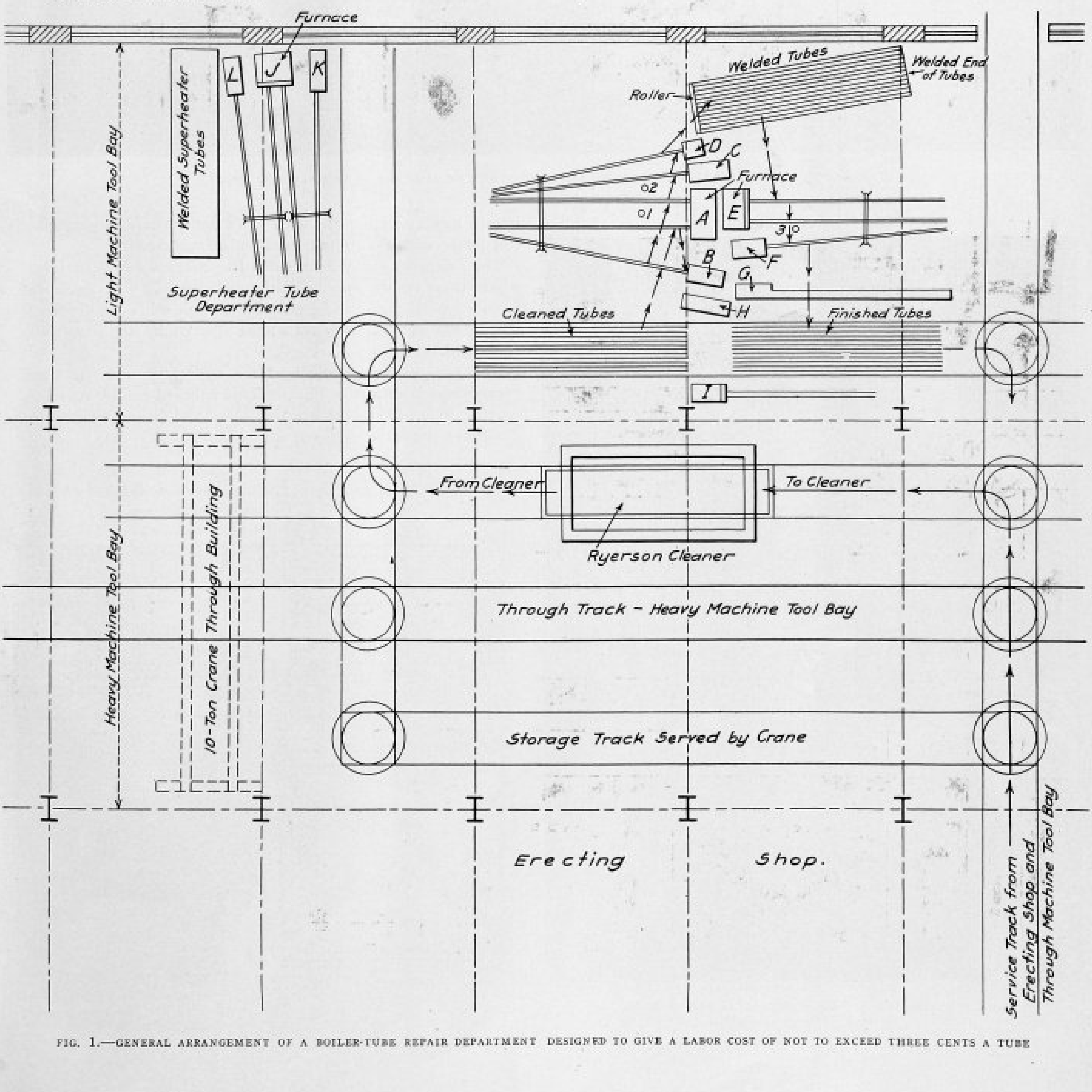


FIG. 1.—GENERAL ARRANGEMENT OF A BOILER-TUBE REPAIR DEPARTMENT DESIGNED TO GIVE A LABOR COST OF NOT TO EXCEED THREE CENTS A TUBE

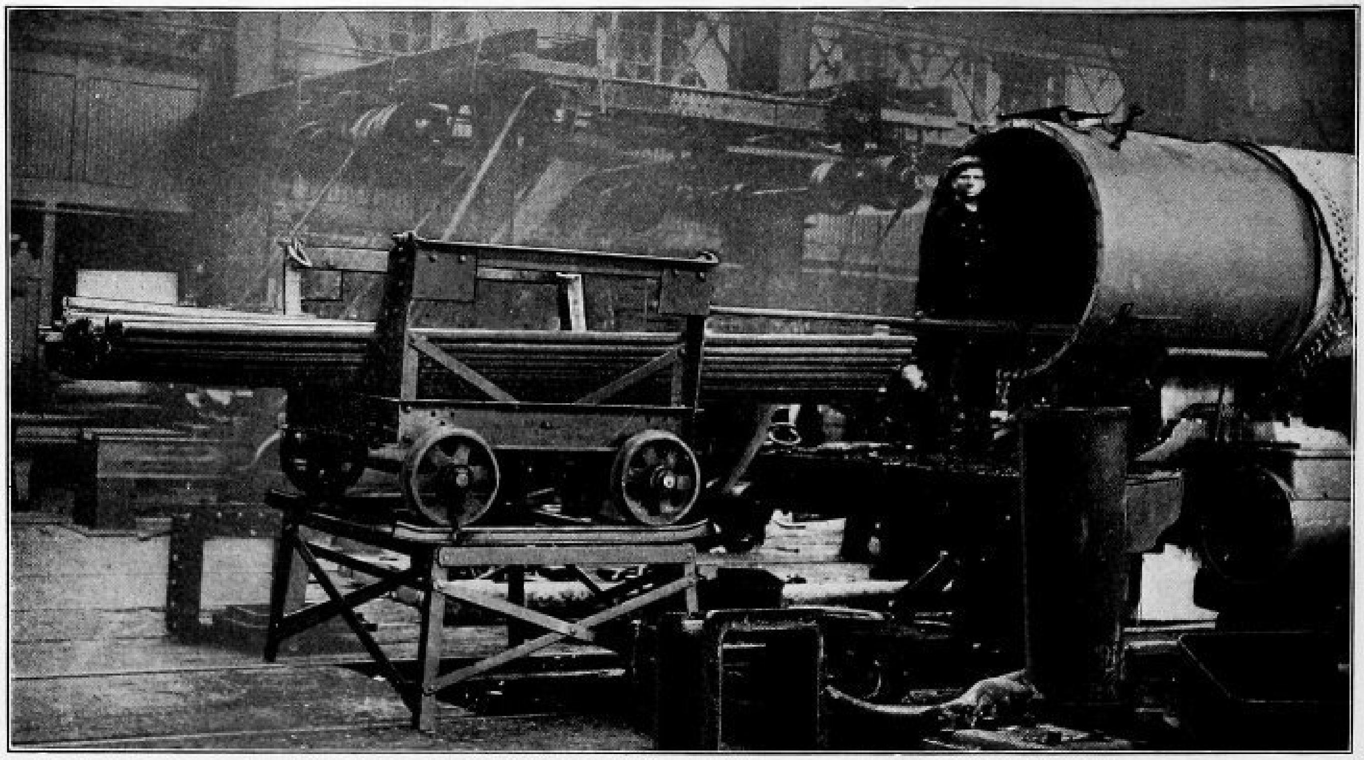


FIG. 2.—REMOVING TUBES FROM THE BOILER AND LOADING ON THE FLUE CAR IN THE ERECTING SHOP

known appliances for this work does not hesitate to guarantee this figure with the proper tools and arrangement.

The following study is intended to outline a flue department where these results may be easily obtained. This arrangement is only typical, and can be modified to suit other conditions if the apparatus and sequence of the operations are practically preserved.

The general arrangement of the apparatus and the track connections is shown in Fig. 1. This is based on the traveling type of shop, where the erecting shop and boiler department are under the same roof and where the machine shop is placed

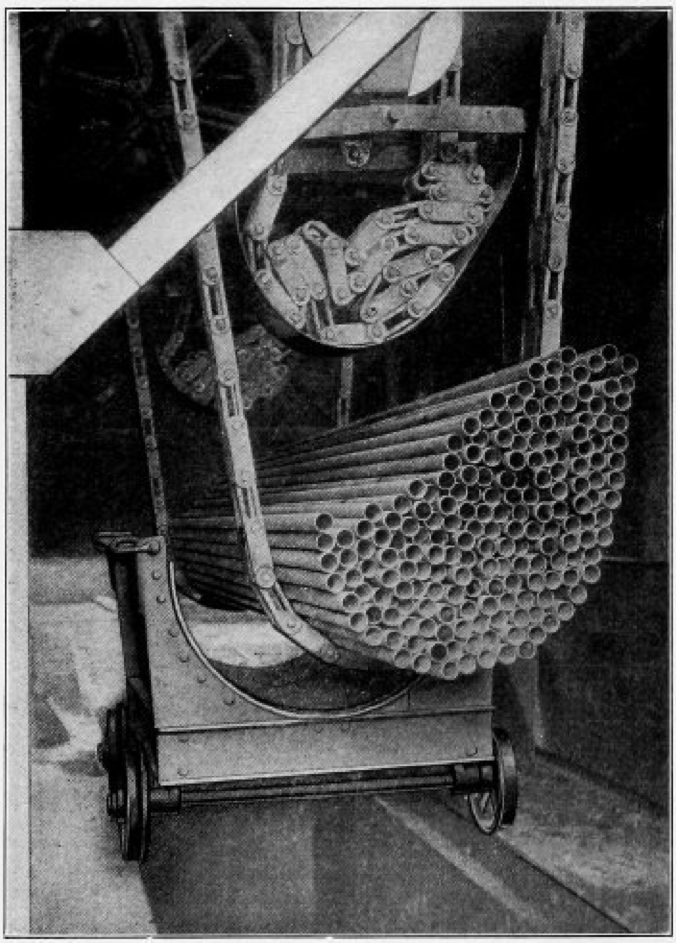


FIG. 3.—REMOVING OR LOADING FLUES AT THE CLEANER

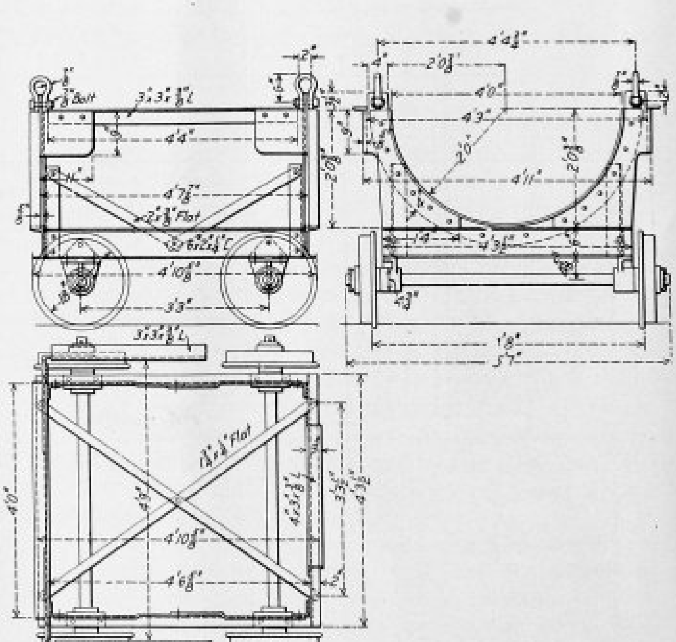


FIG. 4.—DETAILS OF A FLUE CAR ARRANGED FOR TIERING, CANADIAN PACIFIC

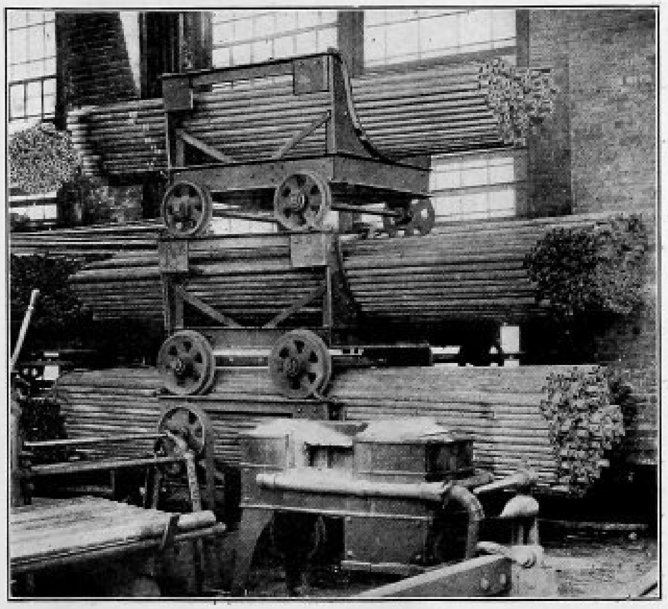


FIG. 5.—METHOD OF TIERING FLUE CARS ON STORAGE TRACKS, EACH CAR HOLDS ONE COMPLETE SET OF TUBES

alongside the erecting shop. This plan is suited to either a transverse or longitudinal track arrangement in the erecting shop. The figures, 1, 2 and 3, on Fig. 1, show the stations of the workmen performing the consecutive operations. The letters designate the machines as follows:

A—Welding furnace, preferably of the oil type.

B—Hot-saw and expander provided with safe-end magazine, where the safe-ends are automatically delivered.

C—Improved welder. Made adjustable to handle tubes from 1½ inches to 6½ inches in diameter.

D—Tube swedger.

E—Second oil furnace.

F—Hot-saw and expander.

G—Tube tester. (A large number of roads are doing away with the testing of tubes, as they have found that the weld made by means of the modern roller type machine is so uniformly satisfactory that it is safe to omit the test, although it has been found that where the welding has been done by

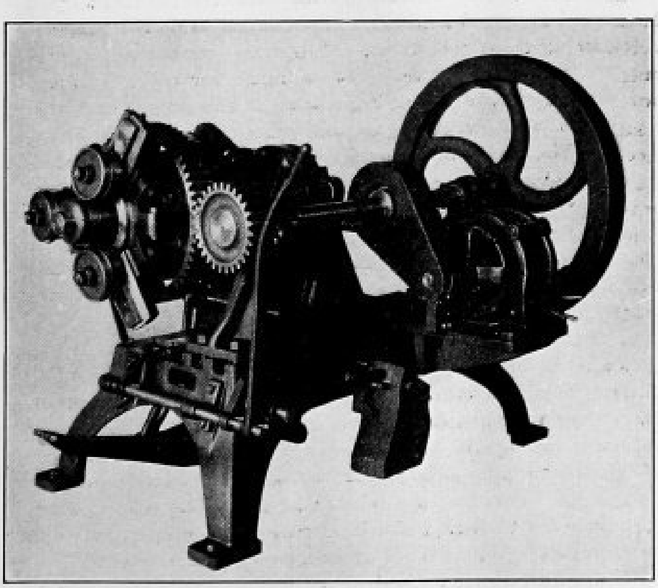


FIG. 6.—HARTZ MOTOR-DRIVEN WELDER WITH GEAR GUARD REMOVED

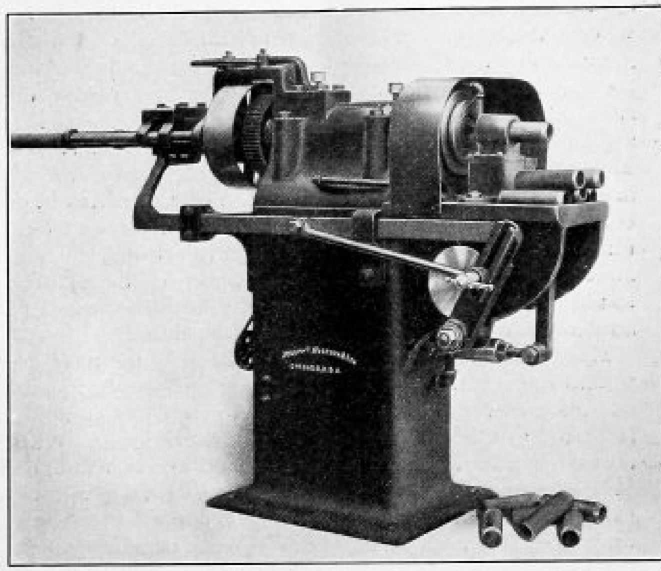


FIG. 7.—MC GRATH SAFE END MACHINE

pneumatic hammers the percentage of poor welds is so large as to make the use of a flue tester necessary.)

H—Rack for storage of safe-ends.

I—Safe-end machine for cutting and scarfing tubes.

J—Furnace for heating superheater flues.

K—Cut-off saw and expander for superheater flues.

L—Welder and swedger, designed for flues from 2 inches to

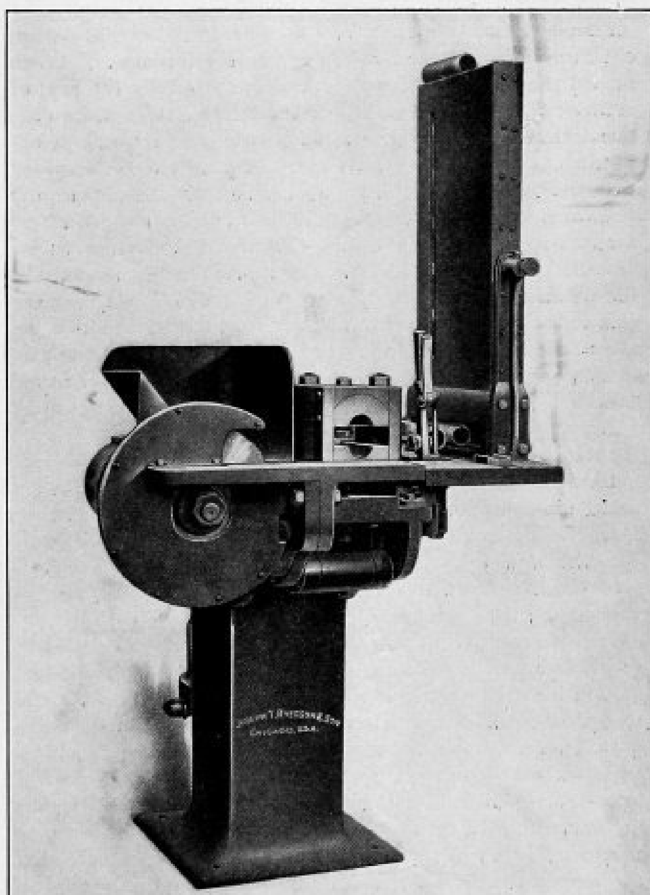


FIG. 8.—HOT SAW AND EXPANDER WITH SAFE END MAGAZINE

6½ inches in diameter. (This machine should be adapted for welding the 4½-inch safe-ends on the small end or full-size 5½ inches on the opposite end of the superheater flue. After the required amount of flues are safe-ended and welded, the adjustment can be changed to perform the operation of swedging and the flues again put through the machine and swedged. This involves another heat; but as the number of superheater flues to be handled per day is so small, it may be advisable, or economical, to use one machine in the manner described, rather than to have a separate machine for swedging. It is, however, obvious that should the number of tubes to be handled warrant a second machine, the operations would be accelerated, especially as one heat could be obviated.)

The method of procedure is as follows: As the tubes are withdrawn from the boiler in the erecting shop they are placed on a flue carrier or car, Fig. 4, conveniently located at the front end of the locomotive, as represented in Fig. 2. When the carrier is loaded it is picked up by the crane, carried to the boiler shop, and set down on the cross-service track, which is usually located between the erecting and the boiler shops. Such a service track at this point is quite common to both the longitudinal and transverse types of shop. The tube car is pushed along this track, in the direction of the arrows, to the track on which the tube cleaner (Fig. 3) is located and then in the cleaner. The tubes, comprising a complete set, are first lifted from the car by the suspending chains as shown in Fig. 3. The car is pushed clear of the machine, and the tubes are lowered in the pit and cleaned. The same chains that raise and lower the tubes in the pit perform the rolling action for cleaning.

After being cleaned the tubes are raised from the pit, the tube car is pushed under them and they are lowered on it. The car is then pushed in the direction indicated by the arrows to the station marked "Cleaned Tubes."

Man No. 1 takes a tube from the pile on the car, and without turning inserts the fire-box end in the furnace *A*. When heated the scored or damaged end is cut off by the saw of machine *B*. The tube is then placed in the clamps and on the mandrel alongside the saw on this machine, where it is expanded and placed on a safe-end. The machine is provided with a magazine from which the safe-ends are automatically fed down in place at the side of the expander. The work so far has required but one heat. The tube, with safe-end attached, is then returned by the same man to the furnace *A* for a welding heat. When heated, man No. 2 takes it from the furnace and welds it on the welder *C*, after which, with the same heat, he swedges the end on machine *D* to accommodate the copper ferrule. It is then delivered to the rack marked "Welded Tubes."

Man No. 3 takes the tube from the welded pile and heats the smoke-box end in furnace *E*. It will be noted that he does not have to turn the tube end for end. After heating, it is cut to length and the end is expanded on the machine *F*; when finished it is placed on the pile marked "Finished Tubes." This pile, or rack, is on a flue car, and when the set is complete the car is pushed back, either to the erecting shop or to the storage track.

In this layout two thoughts have been kept in mind. First, to keep clear of the through track in the heavy machine-tool bay, which it is very desirable to keep free and clear from end to end of the shop; and, second, the tube manipulations are not dependent upon the crane service in the heavy machine-tool bay, and therefore are not affected by any delays incident to the crane being in use when it may be greatly desired for lifting and handling tubes. Yet it is possible to use this crane as an auxiliary, when expedient to do so. It will be noted that the storage track is located in the heavy machine-tool bay parallel to the main or track service, so that in the case of the desirability of tiering the flue cars, to economize space, as shown in Fig. 5, the crane can be utilized, but it is obvious that dependence on the crane for the simple purpose of storage manipulation will not entail any delay in the tube operations.

The overhead type of flue cleaner mentioned above is shown in Fig. 3. The capacity of this machine is 500 2-inch tubes up to 24 feet long. This machine raises and lowers the tubes in the pit by its own power, and may be loaded and started in less than eight minutes and unloaded in the same length of time. It will clean 500 tubes in the same time that the ordinary tube-rattler or tumbler-barrel will take to clean one load of approximately 120 tubes and with much less consumption of power. It consists of an overhead, structural steel framework of heavy construction, supported by four columns. Four steel sprocket wheels, provided with suitable driving gear, are mounted on this, and wide face, case-hardened driving chains pass over them and under a steel idler pulley, and form two loops or slings of equal length, which extend in the pit beneath the framework and support the tubes. By driving the sprockets, the chains cause the tubes to roll over and over on themselves in the cradle formed by the loops. The pair of sprockets carrying the rear chain is mounted on a traverse or bridge, which has a movement to and from the driving end of the machine. The main shaft carrying the sprockets is splined so that by turning the screws which operate the traverse the position of the rear sprockets may be changed and the distances between the two slings modified to suit the length of the tubes being handled. The power of the machine is utilized for changing the position of the traverse carriage.

This machine is also made in another form called pit drive type which has no overhead framework. All the framework necessary for the handling and cleaning of the tubes is integral with the pit itself and below the floor line of the shop. With this type some form of crane or hoist has to be provided to lift the tubes in and out of the pit. The sling chains used for lifting from the car are loosened and remain around the tubes in a recess provided while the tubes are being cleaned. The operation of cleaning is performed in the same way as that described for the overhead type, and either will clean sufficient tubes to give the output assumed for this ideal shop.

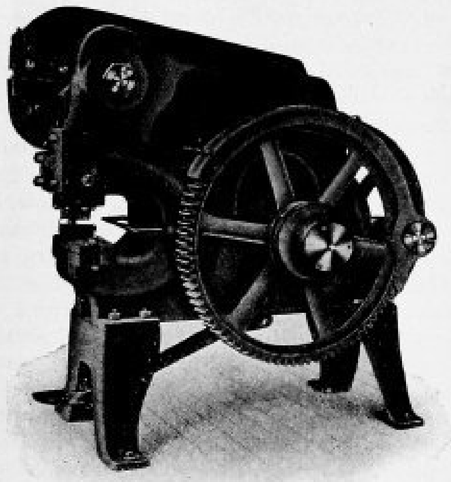
The type of flue car in use at the Angus shops of the Canadian Pacific, which is suited for tiering, one on top of the other, for storage purposes, is shown in Figs. 2, 4 and 5. The type of car shown in Fig. 3 is the general form used where it is not deemed necessary to tier the cars.

The form of flue welding machine selected for this shop is shown in Fig. 6. The machine is designed to do the complete welding in three operations, and operates on the roller principle. In its latest form it has a range for tubes from 1½ inches to 6½ inches. The adjustment of the rolls is such that a smooth weld, true to gage and practically invisible, is assured. The attachments for the cutting-off, swedging, spreading and scarfing operations can be applied, but owing to the capacity of the machine it is mainly used for welding. In the handling of superheater flues these various attachments may be used to advantage, as the time to change the machine for the different operations is not a serious disadvantage, owing to the small number of flues to be handled a day.

The safe-end cutting-off machine assumed is shown in Fig. 7. This is designed to automatically and correctly cut off to length, scarf and finish safe-ends in any length up to 12 inches, and is so arranged that either stock or scrap tubing can be utilized. In general it resembles the ordinary screw machine in that it consists of a substantial base, and means are provided for supporting the tube to be cut. The tube is automatically fed through a chuck, arranged with proper cutters to perform the operations for any degree of scarf or bevel.

If the customary method of cutting safe-ends on a hollow spindle turret lathe or a pipe machine is followed it will not

Doing Two Things at Once is the Accomplishment of the Age



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Think it over if you want to cut down shop costs.

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Specifications

SIZE NUMBER.	Depth of Throat.	Capacity of Punch.	Capacity Shear Rounds.	Capacity Shear Flats.	Capacity Shear Angles.	H. P. Required.	Weight.
1051	5 inches	⅜ x ⅜	⅞ inches	¼ x 4	1½ x 1½ x ¼	2½	1,050
1052	6 inches	½ x ½	1 inches	⅜ x 6	2 x 2 x ¼	3	1,650
1053	7 inches	⅝ x ⅝	1¼ inches	⅝ x 4	3 x 3 x ¼	3½	2,700
1054	8 inches	¾ x ¾	1½ inches	¾ x 4	3 x 3 x ⅜	5	3,250
1055	10 inches	1 x ¾	1¾ inches	⅞ x 4	4 x 4 x ⅜	5	5,000

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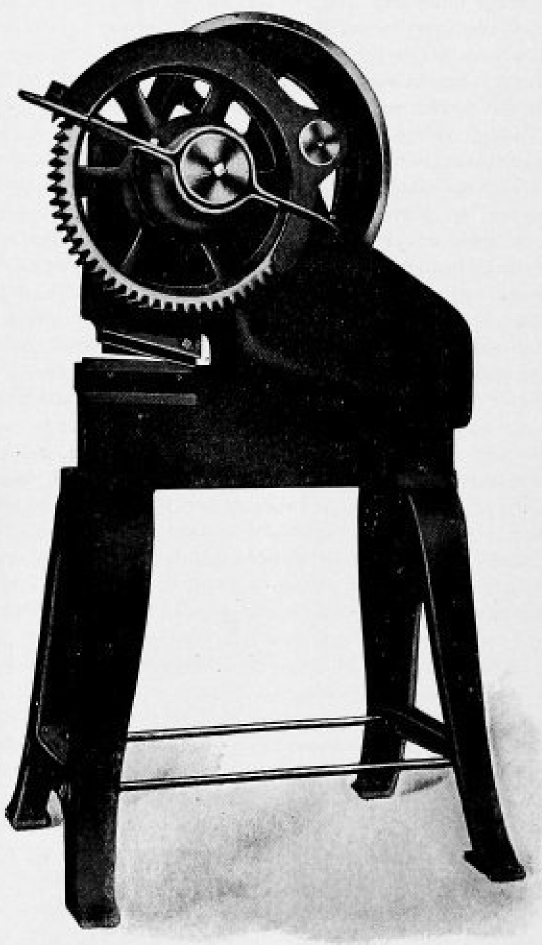

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be possible to attain the price of 3 cents per tube which the arrangement and apparatus under discussion will give.

A Ryerson combination hot-saw and tube expander forms a very vital part of the suggested equipment. This machine (Fig. 8) is arranged to perform three operations, namely, cutting, expanding and picking up the safe-end. A suitable groove is provided for holding the safe-end, to enable it to be driven on to the end of the tube as described above. There is also a magazine for holding the supply of safe-ends which will automatically permit one to roll in the groove after the one in place has been removed. The saw is supported on a mandrel on the left side of the stand as the operator faces it. It operates at high speed and requires but a fraction of a second to cut off the end of the heated tube. A metal chute is provided for removing the hot fag end. The saw is protected by a hood, and is only exposed at the point where the cutting is done. The tube clamping device consists of a lower stationary jaw and an upper jaw mounted on a lever, which, in turn, is connected with a pneumatic cylinder. A horizontal cylinder is located directly back of the tube clamp, and the end of the piston rod is provided with a taper mandrel extending between the jaws of the clamp. The operating lever is so connected with the valves controlling the two cylinders that when it is brought forward the clamp jaws close, holding the heated tube in place while the expanding mandrel is forced in the end of the tube.

Modern Boiler Problems*

BY COL. E. D. MEIER†

In early steam-engine practice very low pressures were found ample, and 10 to 20 pounds per square inch was good practice. Boilers single riveted, even in the longitudinal seams, were common. At the time of the Civil War there were still some boilers in use in the Philadelphia Water Works built of wooden staves and hooped with iron, like casks, amply strong to sustain the low-pressure carried. Of course, they were internally fired, with copper fire-boxes and flues. Higher pressures were, however, soon found necessary on the rivers of the West, the Ohio, Mississippi, Missouri and their tributaries, owing to the shallow water, the shifting channel, and the frequent sand-bars which had to be almost walked over by the boats, raised in front by stilt-like timbers with block and falls and capstan, while the huge wheels churned sand and mud in the slowly deepening channel.

"The furnace crammed rosin and pine" was not John Hay's fancy, but a frequent and menacing fact; and the boilers which must do the work "with a nigger squat on the safety valve" were all hand-riveted, and with cold rivets at that. But the Tennessee furnaces and rolling mills furnished boiler plate and rivets of real charcoal iron, whose virtues were such that it took years of patient study and costly experiment before steel mills could equal and finally excel them. It is true that a trip on the Mississippi, especially if there was a race on for high stakes, was more dangerous than a fierce Central American battle of to-day; but this strenuous rivalry developed a class of rough-and-ready engineers, fertile of resource, quick of apprehension and fearless to a fault. They established by a process of elimination certain standards of construction and safety.

When some decades later Congress established the Steamboat Inspection Service, the law was forced to accept these very standards by an evasion of its grammatical construction.

We must here give credit to a Quaker ironmaster, Mr. Huston, for his persistent arguments in favor of good materials and his demand for testing all boiler plates before they can be used in boilers on the navigable waters of the United States. The phenomenal reduction in loss of life and property in the first three decades of this Inspection Service is his deserved requiem.

Not only in pressure, but also in capacity, the Western rivers furnished the precedents. You can find in the "Transactions of the American Society of Mechanical Engineers" of less than thirty years back grave discussion among eminent engineers as to whether it was advisable to burn more than 8 or 10 pounds of coal per square foot of grate per hour, and from 12 to 15 pounds was considered forcing. But when the Western river boats perforce turned from wood to coal, and led their exhaust up their tall smokestacks, 40 pounds became normal practice there. This on Western coals would be about equivalent to 30 pounds on Cumberland or Pocahontas, and that is now being reached in many larger power plants; and the 50-foot chimneys which were the rule throughout the East in the early 80s have given way to towering stacks of 200 to 300 feet.

The type of boiler naturally changed with the changed requirements. For some time, indeed, the large internally-fired Scotch marine boiler, by reason of its immense prestige on the transatlantic liners, was favored for large plants on shore. Ingenious inventors devised corrugated furnaces strong in construction and effective in evaporation; but increasing pressures and demands for larger capacity made their construction more and more difficult. The necessity for meeting a sudden peak load promptly barred out a construction which demanded hours for safely getting up steam.

At Santiago the engineers on the *Brooklyn* took grave risks of court-martial in firing up their Scotch marine boilers in three hours, when regulations demanded six; and the *Oregon* caught the *Colon* because Engineer Milligan had the courage to keep fires banked in that battery of boilers which the economical Admiral had ordered to stand idle.

Finally, the old saw to first catch your hare before you cook him found its application here.

It is true that in English practice with coals having a minimum of volatile combustible, and moderate demands for capacity, the internally-fired boiler gave good results; but our long-flamed coals and maximum volatile combustible, and forced combustion to meet increased demands for power without sacrificing economy, made it imperative that the furnace must be a prime factor in the design of the boiler plant. An internally-fired boiler furnishes an excellent water-jacket to cool the contents of the furnace.

To obtain the best combustion, a large combustion chamber of refractory non-conducting material, with space enough for air and gas to mix thoroughly and move slowly, is a prime essential.

This can only be met by a watertube boiler, which can be built wide and low, or narrow and high, as local space conditions demand. Again, for the high pressures demanded by quadruple-expansion engines and turbines the watertube boiler offers practically unlimited opportunity for safe design. It alone possesses the elasticity necessary to meet the expansion strains due to sudden forcing of the fires to meet peak loads.

* Lecture delivered to the Stevens Engineering Society, Feb. 29, and published in the *Stevens Indicator*, October, 1912.

† Past-president American Society of Mechanical Engineers; president American Boiler Manufacturers' Association, etc.

These virtues of the watertube boiler were recognized by engineers many years ago; but materials, tools and methods of construction were not then available for the designer.

As early as 1841, Dr. Alban, of Plauen, in Germany, built a watertube boiler which may be considered the patriarch of the tribe. If any of you have the good fortune to travel abroad to recuperate from your too close devotion to your studies—especially thermodynamics—I advise you to go to Munich and spend at least a week in the German Museum for the masterpieces of the technical arts. You will come home, as I did, wishing we had such a museum in every large city of our land. Nowhere in art gallery or historical museum can be found such a comprehensive and instructive exhibit of the progress of the race from ignorance and superstition to civilization and light as on those acres of floor space where German assiduity and patience, civic patriotism and liberality have sought out and arranged with such wonderful system this grand collection of the appliances which made civilization possible. Incidentally you will find in its proper place Dr. Alban's little boiler, and wonder at his temerity in designing and building it with the inadequate tools and inferior materials available in his day. You will also see that he had the prescience to understand the principles on which the safety, the durability and the efficiency of the watertube boiler depend.

Let us enumerate them here:

1. A vessel to contain liquids or gases under high-pressure should preferably have a cylindrical or spherical form. The shells or drums of the watertube boiler are cylinders with spherical heads, and require a minimum of bracing. The tubes are cylinders and have only internal pressure to resist, clearly the ideal stress for metal of great tensile strength.

2. The greater the subdivision of the water and the more surface exposed to heated gases, the more rapid the translation of the heat converting the water into steam. The watertube boiler fulfills these conditions.

3. Water in rapid motion absorbs heat most quickly, because steam bubbles are swept away as soon as formed, and fresh, and hence cooler, films of water constantly meet the heated surfaces. This circulation is the very life of the watertube boiler.

4. Overheating and injury to metal surfaces are best prevented by water in rapid circulation.

5. Heating surfaces should be kept clear of scale and mud. It is much easier to clean and inspect the inside of watertubes than the cramped spaces between firetubes.

6. Accumulations of soot and ashes in boilers diminish their efficiency. They are readily cleared off in watertube boilers by individual soot blowers, or combined blast from nozzles suddenly multiplying the natural draft.

7. Perfect combustion requires a hot furnace and plenty of space and time. Only watertube boilers impose no limit on the designer in this regard.

8. The circulation of the hot gases must be kept under control as to speed and direction. Baffles easily inserted and exchangeable fulfill this condition in watertube boilers.

9. The heating surfaces, if injured by accident, must be easy to repair. In watertube boilers the tubes are the most exposed to such accident, and are most easily replaced without disturbing the settings.

10. Surging, foaming and changes in the water level must be avoided. The chain circulation in watertube boilers utilizes the inertia of a great body of water in rapid motion to resist such fluctuations.

11. The weight of boilers must be kept as low as possible, both for shipment and for floor loads. Watertube boilers weigh less and contain less water per horsepower than any other type.

12. Adaptability space available. As the drums are small, and the vertical and horizontal pitch of the tubes a matter of a few inches, the watertube boiler can be readily designed to utilize any space to best advantage. This also makes it adaptable to all types of furnaces or stokers.

All these advantages conduce also to greater safety, and although the growth of the watertube boiler industry has been very great, there have not been many serious ruptures or explosions. The very few which can be justly termed disastrous are directly traceable to faulty design, or neglect of the most necessary precautions in operating.

The watertube boiler having then established its peculiar fitness for modern conditions, let us consider first the materials for its construction.

Although Lukens, in Coatesville, Pa., began to roll iron boiler plate soon after the Revolution, we were still importing Low Moor iron as a standard boiler plate in 1867. About this time Park Bros. and Hussey, Wells & Company, in Pittsburg, began to make excellent plate from crucible steel, which cost more than, and had not all the good qualities of, the marvelously ductile charcoal iron rolled by the Hillmans, of Tennessee. Some years later acid open-hearth steel was produced by a number of mills, and early in the 80s the Otis Steel Company, of Cleveland, under the able management of Samuel Wellman, gained pre-eminence for the excellence of their plate. Steel plate then was specified solely by the brand, and such terms as flange, fire-box, or extra soft steel had rather indefinite meanings, and the steel was bought on faith, rather than on knowledge; but when pressures began to rise from 50 pounds to 100 and over, conscientious boiler makers began to demand facts in place of names.

In October, 1889, a committee appointed by the American Boiler Manufacturers' Association reported a set of specifications for open-hearth steel. These were debated for an entire day, with able engineers representing the steel mills on the floor of the convention, and a fair compromise finally unanimously agreed upon. The material thus specified was called American Boiler Manufacturers' Association steel; and it was agreed that such a brand would guarantee the qualities agreed on.

While there may have been some private specifications before this, the American Boiler Manufacturers' Association specifications were the first ordained and published by a national society. The qualities prescribed were, in short, as follows:

"Open-hearth steel plate having not more than 0.03 percent sulphur, nor more than 0.04 percent phosphorus; tensile strength between 55,000 and 65,000 pounds; elongation 22 to 25 percent in 8 inches; specimen to bend double on itself both cold and after quenching from red-hot without showing cracks."

In the early 90s there was some murmuring among steel merchants about the low phosphorus limit, but practical demonstrations showed its justice, and the gradual complete adoption of the basic process in open-hearth furnaces made general acquiescence easy. In 1897 it gave me great pleasure to be able to report to the convention of the American Boiler Manufacturers' Association that in more than 250 tests of steel from eight different mills the upper limit in sulphur and in phosphorus had not once been reached, from which I concluded that if you "give American steel mills fair and just specifications, their generous rivalry in excellence will result in product better than you prescribe."

Since 1902 the marvelous increase in iron and steel production has made careful selection of ores more difficult, and various attempts have been made to have us permit an increase in the sulphur limit, but the American Boiler Manufacturers' Association has solidly refused to countenance such backsliding.

Sulphur makes iron and steel "red-short," *i. e.*, brittle at red heat. Phosphorus makes them "cold short," *i. e.*, brittle at low temperatures. Both in excess would endanger the work while flanging, bending, or modeling when hot, and again after cooling down. If boiler makers and boiler tenders were all white-robed angels we might relax in our specifications; but as they are fallible men, with lapses after lodge nights and on blue Mondays, we must stand on the line drawn twenty-two years ago.

Such steel can safely be depended upon with a factor of safety of five (some laws allow four), and as its lowest tensile strength is about one-third greater than that of the best of the old iron plate, and the elastic limit generally considerably more than half the tensile strength, the same thicknesses of metal make pressure 40 percent higher than formerly equally safe. Add to this the general adoption of the double-riveted, double-butt joint in place of the lap joint, bringing the value of the seam up from 68 percent to about 82 percent, and, roughly speaking, we can take care of pressures 50 percent greater than twenty years ago.

Large furnaces for heating an entire flange length instead of short sections, and for annealing after all work tending to distort or set up shrinkage strains has been done, insure that the actual structure will carry out the promise of the test piece.

Cast iron used before 1890 very generally for reinforcing manholes, for feed and blow-off pads and for steam saddles, was emphatically condemned in the American Boiler Manufacturers' Association. Specifications of 1889 and forged steel of best quality are now used for such parts. Cast iron for parts under tensile stress was prohibited, and in 1895 the greatest boiler company of the country marked 125 pounds as the upper limit for cast iron headers.

For some years an uncanny metal called "flowed steel," unknown to metallurgical experts, was recommended to a credulous and undiscriminating public, but it has faded away into the "Niffelheim" from which it came.

Rivets and stays are now made from steel of the same high quality as boiler plate. The forms of stays have been determined by natural selection from long experience, and are now pretty well standardized. There was much prejudice against steel rivets for some years, and high-grade charcoal-iron rivets were prescribed by leading authorities, even after steel plates came into general use. This led to absurd results in following rules which were perfectly rational when charcoal iron was used both in plates and rivets.

At a hearing before the Board of Supervising Inspectors of the United States Steamboat Inspection Service some few years ago a practical boiler manufacturer proved that for steel plate and iron rivets these rules give larger results for standard than for maximum conditions.

The prejudice against steel rivets was finally overcome by the rational work of the rivet makers in demonstrating proper methods of heating and driving, differing much from those in vogue with iron rivets.

Tubes also have undergone progressive evolution. When charcoal iron was still produced in American blast furnaces, and charcoal-iron merchant bars rolled in our rolling mills, the top and bottom plates of the packs from which the skelp was rolled were real charcoal iron; and as most of the wrought scrap which formed the body of the pack was also charcoal iron the steam hammer and the blooming mill turned out an approximately homogeneous bar that had so strong a family resemblance to charcoal iron that the skelp rolled from it could flatly insist on its right to that honored name. Charcoal-iron tubes of excellent and standard quality were turned out, and established a prestige which still adumbrates their degenerate descendants. These tubes had, however, certain defects even in the heyday of their fame. First, they had that fault known as "fiber," so long praised as a virtue. Analyzed, this means that they had their greatest strength in one direction, lengthwise, like a rope, and like it the cohesion at right angles was much weaker. In a watertube it means that the longitudinal seam, which should be strong, is weak; and the circular seam, which might be weak, is strong. In case of rupture it means a split so long that the failure is total, and the disaster proportionate to the ratio of one tube volume to the total contents of the boiler.

As the pack never quite reaches a welding heat, there are innumerable small cracks or fissures in the skelp closed, but without adhesion, and a large number of laminations in the walls of the finished tube. These invite and promote blistering and corrosion from the outside by the sulphurous acid in the coal flame. Having experienced this in the Low Moor iron of locomotive fire-box plates, I naturally expected it in tubes, and I found that these troubles grew in about the same ratio as steel chips and cuttings replaced charcoal iron in all scrap piles.

The first steel tubes were Bessemer steel, and of a sufficiently low grade to permit thorough welding. The heats and methods for welding were soon learned, and we got good service from these tubes. Under tests to destruction they split oftener in the solid than in the weld, and their strength was fifteen to twenty times the stress due to the highest steam pressure carried. As some fault must always be found with new things, the cry was raised that steel tubes corroded more rapidly from impure water than the good old charcoal-iron tubes of blessed memory.

The United States Navy Department carried on a series of tests with various corrosive solutions at McKeesport for a period of three months. The report of the commission sums up that there was only a slight difference in corrosion between the (so-called) "charcoal" iron and the steel tubes, and that in favor of the latter. The greatest solvent of metals is pure water, which we don't get in a boiler where there is always a protective film of scale; and in the last analysis corrosion and solution are active only in *stagnant* water, and that does not exist in a watertube boiler; for there "the circulation is the life," as it is in our own bodies. That cry may therefore be disregarded.

About three years ago the largest tube mill in the country publicly announced that it would no longer make the so-called "charcoal" iron tubes. Meanwhile various plans were worked out to make seamless tubes of steel. The brilliant scheme of the Mannesmann Bros., which, through their exhibit at the Chicago World's Fair in 1893 captivated all experts, after herculean efforts and an expenditure of a fortune on their part proved an industrial failure. Only copper, certain kinds of brass and the most homogeneous open-hearth steel could endure the stress of their high-speed rolls. One of their engineers, Mr. Stifel, came to the United States and developed a modification of their process, which became a commercial success; and during the last five years the open-hearth steel, hot-rolled, seamless tubes have become the standard for high-grade work. Only architects now specify charcoal-iron tubes. Their reverence for the antique is touching and laudable, but should not be extended to metallurgy, which is an essentially modern science.

Some years ago I made exhaustive tests on various makes of steel and iron tubes. The iron ran about 48,000 pounds per square inch tensile strength longitudinally, but only 36,000 transversely, and the steel 59,000 to 60,000 transversely and slightly above 60,000 longitudinally; so that a steel watertube is about 66 percent stronger than an iron one. Occasionally people, impressed by a name but not knowing the process, will specify cold-drawn steel tubes. These are made simply by drawing hot-rolled tubes through dies, just as wire is drawn. This process gives the surfaces a polish at the expense of strength and ductility, and cannot be recommended where safety and durability are prime essentials.

We must now consider methods of manufacture. The tools of the boiler maker have been vastly improved. I have already alluded to large heating furnaces as a necessity for safe and reliable flanging. After the flanging, forming, punching and cutting are done, the finished plates should be brought to a red heat and flattened and smoothed on a planed iron bed by a heavy cast iron roller, not hammered, as was the practice twenty years ago. Powerful hydraulic flanging presses, either unit or sectional, are located near these furnaces, as all such work must be done at a uniform red heat. These also form the spherical heads, headers, manifolds, saddles, nozzles, manholes and pads of best mild open-hearth steel. Castings for such purposes are out of date.

Punches are now made, the heavier ones hydraulic, and with such delicate adjustment that the pitch of holes can be more accurately held by them than by drills. The objection sometimes raised against punching, that it causes incipient surface cracks, holds only for inferior metal and dull punches; but it is usual to ream holes after punching to correct slight eccentricity in the overlapping holes. Among experienced boiler makers it is an axiom that a plate that will not stand punching is not fit to go into a boiler. For plates above three-quarters of an inch, however, drilling is preferable.

In the tests to destruction of six 42-inch drums at Chicago in 1893 the rivet seams with plain punched holes stood best.

For riveting, the hydraulic, or bull, riveter is the best tool, and modifications of it hung on chains to swing into difficult corners have proved equally successful. There will always be some rivets which cannot be reached by hydraulic riveters. For these, pneumatic hammers have been developed, which do excellent work. Their many small blows are easier on the rivet metal than the few heavy blows of the hand hammer, and being more quickly delivered, the metal has time to flow while still at a red heat. In all work done in iron or steel the treacherous blue heat must be avoided.

Pneumatic tools have been assiduously and successfully developed for chipping, calking, reaming, drilling, and even for rolling in tubes, and are now indispensable in boiler shops. The regularity and steadiness of their work save good metal much distress formerly due to injudicious and occasionally too violent muscular effort.

The rotary shears for splitting, trimming and scarfing boiler plate, developed in the West, have taken the place of the plate planer. The work is done quicker, and, when the shear disks are kept properly adjusted, with no distress to the metal.

A plate planer is a heavy and cumbersome tool; but as some engineers insist on its use, it can be stowed away in an unused corner and an electric motor hitched to it in a few minutes when wanted. Bending rolls are made much heavier than formerly, with greater facilities for adjustment and with electric drive. The importance of rolling the whole shell to a true cylinder is recognized in the design of these rolls, and the shell comes off with the edges in contact. The butt straps are brought to the correct curve by a hydraulic press.

A completely equipped machine shop is a necessary adjunct to a modern boiler shop, as saddles, pads, hand-hole plates, etc., must be carefully machined to fit, and all tools kept in the best working condition by constant adjustment and repair. Special tools and appliances must be designed or adjusted for the special work the special type of boiler demands.

A most important element in the equipment of a boiler shop is machinery for handling the material in all stages, including the shipment of the finished product. Various hoists, traveling cranes, jib cranes, etc., are necessary for this, and for some purposes industrial railways must be used. The hoists and cranes are mainly electric and pneumatic, the former for heavy and accurate work and long travel, the latter for quick handling. I recall a case where the delivery of the main traveling crane was delayed, and it cost from $20 to $30 to load a large boiler on cars by truck, jacks and skids. When the crane was completed the same work was done for 80 cents.

All finished work should be tested by hydrostatic pressure, and leaks stopped before calling for official inspection. For this a large supply of water under pressure is requisite. This can generally be taken from the accumulator service, and any desired test pressure reached and the water returned to the service tank.

All the energies should originate in a well-planned power house, where engines, dynamos, compressors and pumps are under the constant surveillance of a careful engineer, who is responsible for the amounts and pressures carried to the shops by the hydraulic and pneumatic pipes and the electric wires.

Such are the means needed to fill the requirements of the designing and consulting engineers, planning the huge power plants required for transportation and various industries.

The size of units required has risen from several hundreds to several thousands of horsepower; the pressures from 100 pounds to 200 pounds and over, and a forcing capacity of from 50 percent to 100 percent is frequently specified. As Prof. Breckenridge truly stated in 1909, "Good, clean heating surface with unimpeded circulation is just aching for more work to do," and the limit is simply in the capacity of furnace and stack to burn enough fuel. Tubes never fail from overwork, but from mud, scale or oil, which should be kept out. There is no difficulty in building watertube boilers of any size. It is simply a question of the judgment of the owner and his engineer as to how many eggs they think it wise to put into one basket.

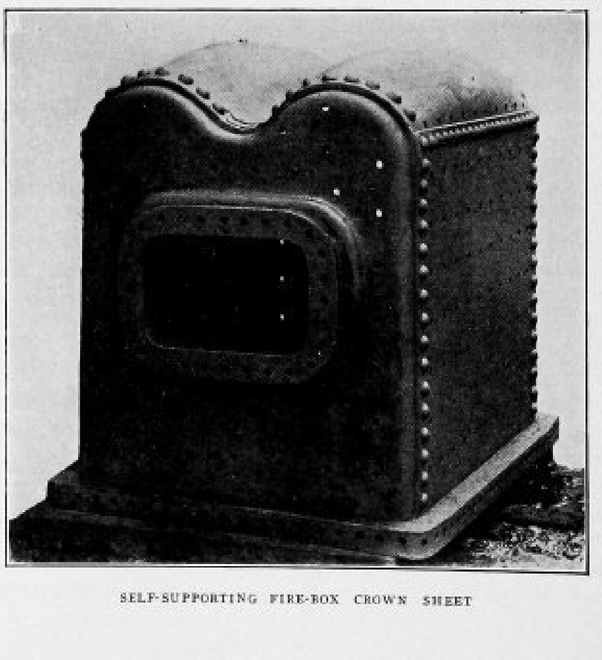
Fire-Box Crowns

BY A. L. HAAS

Fire-box crowns for locomotive type boilers are receiving considerable attention at the present time. The same design of boiler is used with an engine mounted on top of the boiler barrel, such engine and boiler being known as portable, or semi-portable, according to whether the plant is designed with traveling wheels for road service or not.

Such self-contained steam units are extensively made in the United Kingdom, and they are believed to be a peculiarly British production. Sometimes the semi-portable variety has the steam engine occupying the space under boiler barrel, and is then known as an under-type engine.

The greater number of such steam units have boilers of smaller size than the usual regular locomotive. The general



SELF-SUPPORTING FIRE-BOX CROWN SHEET

make and finish, however, compare favorably with similar boilers in railroad service in this country. I may add in parenthesis that the British locomotive boiler in use for railroad service has a remarkable record in freedom from explosion. The number of casualties of this description in railway service may be counted on the fingers of one's hands. It is also remarkable that there is no statutory inspection of such boilers, although every railway casualty is subject to stringent and searching independent inquiry by the Board of Trade, who have very extensive powers. The inspector in such an inquiry is always a salaried official permanently attached to the Board of Trade, and is usually a man of high military rank and an ex-Royal Engineer officer.

Needless to say that every fresh design or improvement adopted by any railway for locomotive boilers is closely scrutinized by the makers of such boilers for other purposes. The practice of the larger lines is closely followed by other sections of the boiler making trade.

Portable engine makers have to study weight, and when the Belpaire fire-box came into vogue it found a ready reception among this trade. This fire-box utilizes for the staying of the crown the same method as applied to the other flat sides of box, *i. e.*, through screwed stays to the outer shell.

Such portable steam engines are frequently attended by unskilled agricultural labor, and are very hard run at certain periods of the year. It is necessary to take particular care that access to the boiler interior is easy by the provision of sufficient mud doors. The older type of roof stays (girder bars) across the box, although a sound mechanical design, has the disadvantage of excessive weight, and the problem has to some extent been solved by the Belpaire box.

Combustion chambers in Scotch marine boilers are now frequently fitted with a semi-circular crown sheet, to obviate the necessity for roof stays at all. But such a solution does not meet the case of the locomotive type boiler, since it sacrifices heating surface and, more undesirable still, increases the quantity of water in the boiler, thus lessening quick steaming power.

A proposal in the case of Scotch boilers to increase the heating surface by fitting Galloway tubes through the combustion chambers has never been adopted. The following was related to the writer concerning this matter:

The British Board of Trade gave sanction for the experiment to be tried, and a steamer was so fitted some years ago. To all appearances the boilers worked well in port and the steamer proceeded on her voyage. The ship never reached port and was never heard of after. Since which time the experiment has not been repeated. Had the run been accomplished, and the boilers proved satisfactory, it is probable that at the present time every Scotch boiler would have been fitted with Galloway tubes through the combustion chamber.

The attempt to obviate the necessity for staying fire-box crowns has received much thought, and many solutions have been proposed during the past fifty years. It is about that time since Messrs. Horton & Kendrick, of Smethwick, England, patented a type of fire-box with a corrugated roof.

In 1876, Messrs. Garrett & Sons, of Leiston, Suffolk, England, patented the type of fire-box shown, and since that date have abandoned any other alternative. The job is a fine piece of flanging, as will be seen, for which work they are very well laid out. It will be noticed that the crown sheet consists of two corrugations and a center depression, the shape resembling closely a dropped crown sheet. The sheet is cambered upward in the direction of the boiler length, the front and tube plates being flanged to correspond with the peculiar shape of the crown sheet.

Conversation elicited the fact that the shape in its inception was due to accident. The firm experimented with a three-corrugation crown and made several. One of the boilers was allowed to get short of water, and the overheated crown, with the heel of the boot of pressure behind it, eliminated the center corrugation. The matter was carefully considered, and further experiment resulted in the shape shown. The shape is thus purely empirical, but the result of investigation and practice extending now some thirty-six years.

One other point is that the fire-boxes are short in comparison with their length; this from comparison with usual locomotive practice. The over-all width of the boiler for a portable engine is not limited by the standard rail gage, this fact making possible a different ratio between the length and width of the box.

From actual experiment made by the writer the deflection in the center of the crown under hydraulic pressure, twice the steam pressure resulted in no deflection at all. Ordinary roof stays (bridge bars) always give a deflection under pressure.

The criticism passed that dirt might accumulate in the center depression of the crown seems to be met by the rapidity of the convection currents at this the hottest part of the boiler. It is not usual to find anything but hard scale on the fire-box crown of any boiler; sediment usually forms in the least active portion of a boiler. Boilers fitted with this box have a manhole of fair size in line with center depression of box, so that when washing out at the usual period, 100 hours' working, the crown sheet cannot be missed.

An analogy may be drawn between the shape of marine boiler furnaces and this fire-box top. The Morison suspension furnace is provided with stiffening rings, and the metal between these is disposed in a catenary curve similar to the Garrett box, so that this box has a first cousin, anyway.

In spite of the long period now elapsed since the patent expired its imitators have been few. Some European railways have adopted a modification, but their experience is not available. The firm making it have the courage of their convictions, since they make no other design, and have thirty-six years' experience to back their belief. Since 1,400 men are employed, and their work is steam engines exclusively, practically every engine being provided with a boiler, there must be a considerable number in existence.

Minor advantages claimed are an increase of 22 percent in heating surface at the most effective spot, and a tendency to free the crown from scale by the alternate expansion and contraction.

In conclusion, my application to make this design public through the pages of THE BOILER MAKER met with instantaneous and generous permission by Mr. Frank Garrett, who kindly furnished me with the necessary photograph and particulars of its history.

LARGE STEEL TANKS CONSTRUCTED.—Two of the largest steel tanks ever constructed in the Northwest were recently completed by the Seattle Construction & Dry Dock Company, Seattle, Wash., for the meat packing plant of Fyre & Company, South Seattle. The tanks are 24 feet in diameter and have a capacity of 20,000 gallons each, weighing 7 tons apiece. The tanks will be used for storage purposes, and the contract called for their construction in record time. Since its reorganization the builders, formerly the Moran Company, one of Seattle's pioneer manufacturing concerns, and now the Seattle Construction & Dry Dock Company, has added materially to its facilities. The company is now doing a large business in the fabrication of steel for structural purposes, for both buildings and bridges, as well as a large amount of shipbuilding work. A new floating drydock of 12,000 tons capacity is under construction, and will be ready for service by the first of the coming year.

The Boiler Maker

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., of THE BOILER MAKER, published monthly at New York, required by the act of August 24, 1912.

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Sworn to and subscribed before me this 2d day of October, 1912.
(Seal) DAVID FISCHER,
Notary Public.
(My commission expires March 30, 1913.)

Information from some of our readers discloses the fact that THE BOILER MAKER is looked upon in certain quarters as an ardent advocate of piecework in the boiler shop. We regret that such a misapprehension should exist, for it has always been our policy, and will continue to be so, to play no favorites in any matter trifling with the cardinal principle of a square deal. Our columns are always open to contributions both for and against any debatable question, and we welcome gladly any information which will tend to throw further light on such a question, provided it is based on personal experience and backed up by sound judgment. The articles dealing with piecework published heretofore can be looked upon as the fruit of long experience and judicial observation, and not in any sense as the outpourings of fanciful, hair-brained theorists. In every case the contributor can produce a record of long-established and efficient service in a responsible position in the boiler making trade, which counts for much in the value of his observations. If anyone else has anything to say for or against the principle of piecework, or any other complex problem of similar interest to boiler makers, we hope he will not hesitate to favor us with his ideas on the subject. Conditions vary in different cases, and it is only by full explanation and intelligent comparison that the wisest course can be determined in any particular case.

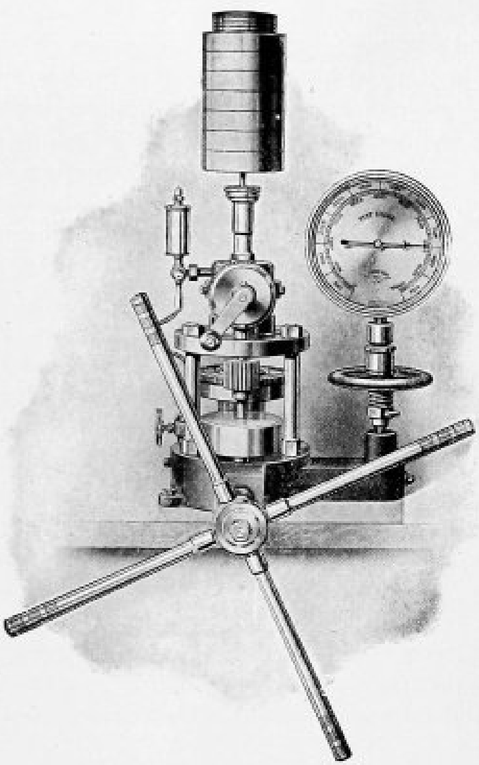
There has always been more or less doubt as to the value of different parts of the heating surface in a boiler. The tests of a large watertube boiler described in this issue throw much light on this doubtful question and admirably supplement the results obtained recently in tests of locomotive boilers to determine the relative value of firebox and tube heating surface. It will be recalled that in a locomotive boiler the firebox heating surface proved to be more than seven times as efficient as the tube heating surface. In the watertube boiler, where the gases made three passes through the boiler, the second and third passes constituting 50 percent of the boiler heating surface, it was found that, at less than 75 percent of boiler rating, the heat absorbed in the second and third passes was only about 1.3 percent of the total, and that it was only when the boiler had reached 75 percent rating or more that the gain in economy in the last two passes was sufficient to give a reasonable return from the investment in this heating surface. What the conditions are in the ordinary horizontal tubular boiler and the Scotch boiler would be interesting to know, as the relative value of the different portions of heating surface for the transmission of heat certainly has an important bearing on the design of the boiler. It is hoped that an opportunity will be found to determine this information at no distant date.

The possibility of improving the arrangement of machine tools in a boiler shop and providing a more expeditious sequence of operations on any job and thereby reducing the cost of the work and saving some of the time ordinarily allotted for its accomplishment, is too often overlooked. An instance of this is cited in this issue in the discussion of the arrangement and equipment of a so-called ideal boiler tube department for a locomotive repair shop whereby the cost of repairing boiler tubes can be reduced to a figure less than half the former cost. That such a saving is possible on some of the ordinary work in a boiler shop where it is least expected may surprise a good many boiler makers, but the possibility of doing this is worth investigating. Even when it is impossible to replace old equipment with modern machinery a careful analysis of the various operations involved in the work may disclose opportunities to save something by a simple change in the arrangement of the old machinery and a change in the sequence of operations.

New Improved Engineering Specialties for Boiler-Making

The American Multipar Hydraulic Deadweight Tester

The American Steam Gauge & Valve Manufacturing Company, Boston, Mass., has placed on the market a hydraulic deadweight tester where each 10-ounce weight will positively calibrate from 1 pound to 100 pounds pressure per square inch, and a 6¼-pound weight will as accurately calibrate from 100 to 1,000 pounds pressure per square inch. Multiples of these deadweights make its usefulness practically unlimited, it being as simple to calibrate a 25,000-pound gage as one of 5 pounds. This extraordinary range is secured by means of



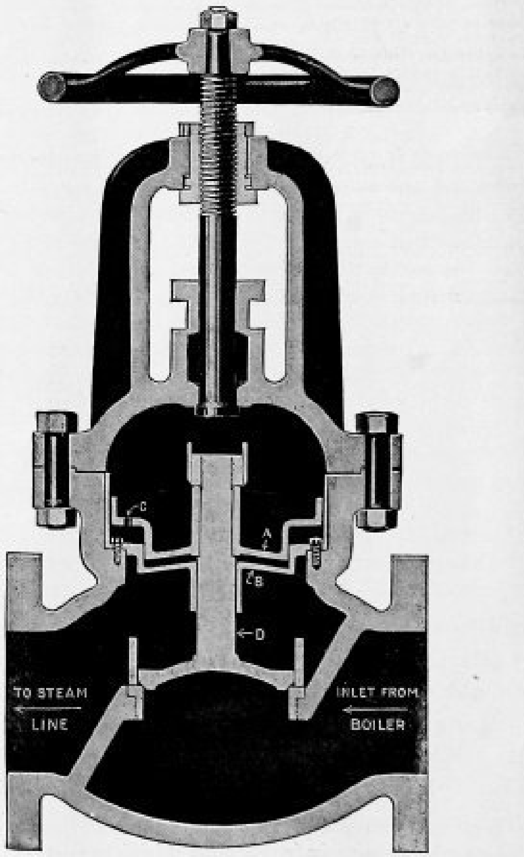
a very simple system of multiple pistons, all of which are fixed and permanent, the third, or top cylinder, having two interchangeable pistons, the larger being used for pressures from 1 to 100 pounds per square inch, the smaller for from 10 pounds to whatever pressure is desired, the outfit as regularly supplied being equipped up to 25,000 pounds per square inch. In operating, a pressure is created by applying weights to the piston in the upper cylinder. This gives a pressure which acts precisely as would weights if applied to the end of the lower piston. It is by means of this upper cylinder that the heretofore insurmountable difficulty of securing great pressure by the use of light weights has been overcome. Low-pressure tests are made by opening a by-pass connecting the upper and lower cylinders, which allows the pressure created by the pressure screw in the lower chamber to connect directly both with the upper chamber and with the gage being tested. The system is thus converted into the original direct deadweight tester.

A Boiler Scale Remedy

The United States Graphite Company, Saginaw, Mich., have on the market a boiler graphite made from the product of mines in Mexico which is claimed to be a sure and safe boiler scale remedy. Owing to the unequal expansion and contraction of the metal of a boiler, and the scale in it, the latter during alternating periods of heating and cooling becomes more or less cracked, and on account of these small cracks pure graphite, suitably prepared and circulating with the water, finds its way through these minute openings, and deposits itself on the inner surface of the tubes and shell between the metal and the scale, with the result that the latter will no longer adhere tenaciously and may be removed with comparative ease. Continued use of this graphite after the boilers have once been cleaned prevents the subsequent accumulation of hard scale. The use of this remedy has the advantage that it does its work without doing any harm to the boiler itself, since its action is mechanical instead of chemical.

Anderson Double-Cushioned Non-Return Valves

The Golden-Anderson Valve Specialty Company, Pittsburg. Pa., has on the market a double cushioned automatic non-return valve of both the globe and angle type. The construction of the valve is apparent from the sectional view shown herewith. When the hand-wheel is run down into the closed

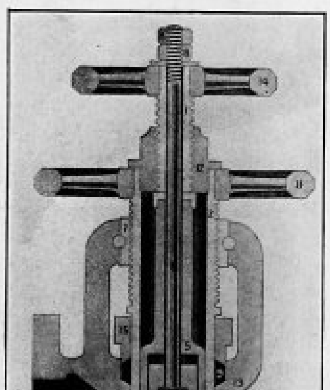


position the valve is shut like any globe valve. The hand-wheel stem, however, merely bears against the valve stem and is not attached to it, so when raised to the open position the valve disk is free to rise and fall under the action of the steam. To the upper end of the valve stem is attached a piston that creates a dash chamber in the top of the valve body above the liner. Through this liner the valve stem passes loosely enough to permit entrance of full pressure to the cushion chamber above the liner and through a small hole in the piston to the chamber above. Steam flowing into the header raises the valve and holds it open so long as the flow continues. If the flow ceases quietly, as when the fires are drawn, the valve settles on to its seat and remains closed against the header pressure. Sudden reversal of steam flow in case of rupture or other accident in the boiler tends to close the valve instantly. This it would do with destructive force were it not for the dash-pot and the cushioning device above the liner. The Corliss dash-pot method of cushioning is employed, occupying the full area of the upper portion of the body of the valve, thus insuring a positive cushion in the opening and closing of the valves and perfect alinement with the seat at all times, regardless of position. The hole through the dash piston permits rapid escape of steam to the chamber above and a quick drop of the valve to within about 1/8 inch of its seat, when the closer fitting secondary cushion comes into action as the lower portion of the piston enters the corresponding depression in the liner, forming a chamber from which the pressure can escape only gradually. The full boiler pressure is always above the dash-pot and the valve will close, at the same time being cushioned in the operation.

These valves are made extra heavy for a working pressure of 350 pounds per square inch. When placed in the boiler outlet the valve will permit the passage of steam to the header or main as required in regular service, but will close quickly against the reversal of the flow of steam. In case of accident to the boiler this valve will isolate the disabled unit from the rest of the battery, thereby not only reducing the destructive results of the accident, but also confining the damage to this one boiler, and avoiding oftentimes the necessity for any interruption in the operation of the rest of the boilers in the battery.

The Eynon-Evans Blow-off Valve

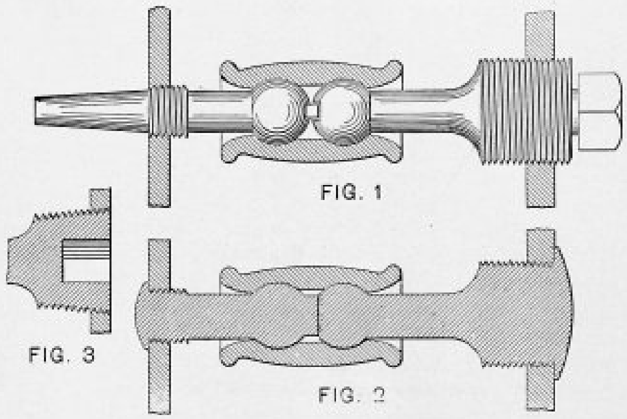
The Eynon-Evans Manufacturing Company, Philadelphia, Pa., has on the market a heavy flanged, nickel blow-off valve, built for the heaviest service. The illustration shows the valve in a closed position. The inlet is connected to the blow-off pipe from the boiler. The body and yoke of the valve



are of iron cast in one piece. A special nickel ring, 3, is secured in the iron body, the inside diameter of which is the same as the inside diameter of the bronze shield, 2, forming a continuous surface for the reception of the packing, 4. This packing is so placed in the ring and shield that it prevents leakage from the inlet to the outlet and around the bronze stem, and can be adjusted or compressed to the desired density while the valve is in service. The upper hand-wheel withdraws the pistons with the packing from the nickel ring into the bronze shield. The shield itself is operated by the lower hand-wheel. The principle involved is that of absolutely protecting the packing inside the shield before the grit, scale and other destructive blow-off products are permitted to pass through the valve from the boiler. The lower end of the shield also acts as a valve, which permits the removal and inspection of the packing, while the blow-off valve is in service with full boiler pressure.

The Twentieth Century Flexible Staybolt

A new type of flexible stay-bolt, known as the Twentieth Century Flexible Stay-Bolt, has been patented by H. A. Lacerda, boiler inspector at the West Albany shops of the New York Central lines. The bolt is composed of three separate parts—the finished bolt being practically a solid, rigid stay-bolt, divided into two parts and joined together by a sleeve. The simple construction of the bolt is shown by the illustration. The part of the bolt which joins the fire-box sheet is of the same size and is threaded in the same manner as an ordinary rigid stay-bolt, except that the end in the water space is pressed into the form of a ball and fitted with



a heavy key. The outer part of the bolt, which joins the outer sheet, has an enlarged end, which is of a greater diameter than the outside diameter of the sleeve which joins the two parts of the bolt together, so that the bolt may be inserted through the hole in the outer sheet. The inner end of this part of the bolt is pressed into the form of a ball, and a keyway is cut in it to receive the key from the other part of the bolt. The sleeve is then pressed around, the joint forming a joint which is flexible, and which at the same time holds the two parts of the bolt in close contact, so that it may be installed and tested as an ordinary rigid stay-bolt. As shown in the illustrations, the bolt may be applied in two different ways, both of which are simple. The inventor claims that the Twentieth Century stay-bolt meets the needs of a flexible bolt, from the fact that its construction permits equal flexibility at each end of the bolt, since it is not restricted by either the inner or outer plates. This type of bolt has been thoroughly tested, the failure occurring in the solid part of the bolt at a stress of a little over 48,000 pounds per square inch. The bolt can be made in two operations, which require only suitable dies for forming the ball joint and sleeve; thus the construction is cheap, as is also the application, since it is applied in exactly the same manner as a rigid bolt. A valuable feature of the bolt is the fact that it can be tested by the hammer test with perfect safety, as is done with rigid stay-bolts. This type of bolt has also been designed for staying crown sheets in place of expansion bolts.

Rivet Calking Machine

Among the recent inventions of interest in the field of boiler and steel plate work is that of a rivet calking tool invented by John Woodward, Leetonia, Ohio. The tool operates on the principle of a double-driving wedge, and is driven by the plunger used in a pneumatic hammer or chipper. The tool is especially efficient, in that it clenches the rivet to the plate, calking on both sides of it (diametrically opposite) at the same time, thereby preventing it from being driven back and forth in the hole. It is claimed the head of the rivet is not scarred or wasted. One important feature in the way of efficiency is that the tool can be worked right up against a head or in the corner of a fire-box, where a boiler maker could not reach with a hand hammer. It is claimed that ten times as many rivets can be calked by this method as can be calked by the old method, where frequently after the rivet has been driven loose in the hole and part of the head cut away the rivet itself has to be cut out. This tool has already been used in boiler shops with good results and will be put on the market shortly.

Personal

B. F. THROCKMORTON, formerly foreman of the boiler department, Erie City Iron Works, Erie, Pa., has taken the postion of foreman boiler maker of The John Brennan & Company, Detroit, Mich.

J. B. CRAWFORD, formerly foreman boiler maker of the Tennessee Coal & Iron Railroad Company, Birmingham, Ala., has just organized the Crawford Boiler & Locomotive Works at 1405 Avenue E, Birmingham, Ala. Mr. Crawford started as apprentice with the Tennessee Coal & Iron Railroad Company in 1886, and in 1890 was appointed assistant foreman. In 1899 he became foreman boiler maker, which position he has filled until the present time.

HARRY W. JARROW has been appointed general sales manager by the Diamond Power Specialty Company, Detroit, Mich. The retaining of Mr. Jarrow by this company is in accord with an extensive selling campaign now being entered into. Mr. Jarrow comes to Detroit from a seven years' association in the mechanical and sales department of The Cable Company, Chicago, where he became assistant manager of sales in the Player Department a year ago. Besides this broad selling experience, Mr. Jarrow brings to the technical side of his new work a mechanical engineering training gained both at the University of Pennsylvania and at the Armour Institute of Technology, Chicago, Ill.

MR. UMLAUF, formerly foreman boiler maker of the Lackawanna Railroad at Buffalo, N. Y., has been appointed foreman boiler maker of the Erie shops at Susquehanna, vice W. G. Vogel, resigned.

LORNE HARTLAND has been recently appointed foreman boiler maker at the Halifax navy yard, Halifax, N. S.

GEORGE E. PARKER, foreman boiler maker of the Chicago & Eastern Illinois Railroad at Villa Grove, Ill., has been appointed foreman boiler maker of the El Paso & Southwestern, with headquarters at Douglas, Ari., vice N. J. Young, resigned.

Obituary

JOHN J. KEEFE, Southern representative of the Independent Pneumatic Tool Company at Atlanta, Ga., died Nov. 20 from an attack of typhoid fever. Mr. Keefe's entire business life was associated with railroad work, either in the mechanical department or the railway supply field.

REUBEN WELLS, 83 years old, died recently at his home in Paterson, N. J. He was a builder of locomotives and an inventor. Starting his career as a machinist apprentice he became the president of the Louisville & Nashville Railway. His grade-climbing locomotive, invented in 1868, was used without being improved for twenty years. The first locomotive of this type which he designed is now in the museum of Purdue University. He was also the superintendent of the Rogers Locomotive Works prior to its merger with the American Locomotive Company.

Technical Publications

Steam Boilers and Boiler Accessories. By W. Inchley, B. Sc. Size, 4¾ by 7¼ inches. Pages, 412. Illustrations, 140. New York, 1912: Longmans, Green & Company. Price, $2.40 net.

As this book is intended to meet the requirements of steam users and engineering students rather than boiler manufacturers, it may seem incomplete to one familiar with the countless details of boiler shop practice. Technical details of boiler construction, such as the pitch of rivets, strength of plate, etc., are purposely omitted, however, since the class of readers for which the book is written is not necessarily concerned with such matters. A general description of various types of firetube and watertube boilers is given, and the questions of fuels and combustion, draft, generation of steam and heat transmission are thoroughly treated. A large amount of space is taken up with the description and explanation of the operation of every conceivable boiler accessory, the final chapters dealing with the practical operation of boilers and carrying out of steam boiler trials.

Oxy-Acetylene Torch Practice. By J. F. Springer. Size, 5 by 7¼ inches. Pages, 140. Numerous illustrations. New York, 1912: The Richardson Press. Price, $2.50 net.

The welding and cutting of metals, particularly of boiler steel, by means of an oxy-acetylene torch, have become of such importance in recent years that most boiler makers are familiar with the general principles of these operations, and many have seen at first hand the results of the practical operation of the process. There is a vast difference, however, between experiment and approved practice, and it is the object of this book to set forth an accurate account of approved practice in the application of oxy-acetylene welding and cutting. The book was prepared with the co-operation of a prominent manufacturer of such apparatus, and is, therefore, based on wide experience and sound judgment. The book is not confined to boiler work; in fact, only a short chapter deals with boiler work; other parts of the book, however, deal in a complete manner with various types of sheet metal work, and of particular interest are chapters which take up the restoration of steel, welding as a calking process, and an investigation of the question as to whether or not oxy-acetylene cutting injures metal.

Practical Design of Marine Single-Ended and Double-Ended Boilers. By John Gray. Size, 5 by 7¼ inches. Pages, 84. Figures, 21. Plates, 4. New York, 1912: D. Van Nostrand Company. Price, $1.25.

It is claimed that this is the only book on the market dealing solely with the design of high-pressure single-ended and double-ended marine boilers. It is true that almost every book on boiler design or construction is concerned chiefly with the general principles of boiler construction and the details of stationary boilers, with perhaps a short chapter devoted to the design of marine boilers. A more complete treatment is needed, however, to enable a draftsman to work out the complete design of a Scotch boiler. In recent years steam pressures have steadily increased on board ship, and as larger ships and greater speed seem to be the prevailing tendencies in modern shipbuilding, it is necessary for the draftsmen or engineers engaged in their design to study in detail the construction of the large four-furnace high-pressure boiler. This book is an admirable aid for this purpose, and a copy should be in the possession of anyone who has to do with the design and construction of marine boilers.

Communications of Interest from Practical Boiler Makers

Piece Work

I have been deeply interested in the communications from some of the readers of The Boiler Maker upon the subject of piece work. My first experience with piece work goes back a good many years. I was then just out of my time and starting out as a journeyman. I was put to work upon some large conductors for blast furnaces. We were to drive 200 5/8-inch rivets for a day's work (nine hours), and were allowed to make one day and a half each day, or a total of 300 rivets. All the work was well fitted up and joints broken and the work rested upon rollers, so there was very little work to turn the pipe; the holes were splendid, and we had a fine rivet heater who was there with the goods. Just as the last blow was struck, so that there would be no waiting, the rivets were snapped with a sharp, deep snap, so that when the rivet was done there was a clean looking job.

The work was counted and examined by the boiler inspector at the close of each day, and the finished work marked with paint, so there could be no miscount. We made out good, and everybody was well pleased with the job. Now, here was a job that was favorable for piece work, as there was nothing to cause delay or trouble, and I think that piece work under these conditions could be worked to advantage, but if the holes were bad, and had to be gouged and pinned out, a gang could not make their salt if they got their meat for nothing.

Since then I have had quite a lot of experience with piece work under its various names—fast work, premium work and individual merit—and want to say right here that the whole thing is a regular humbug, for although the employer gets his work out faster than he did, he is getting it at the expense of good work. For instance, a railway company that I formerly worked for adopted the piece-work system, and on flues they paid 8 cents per flue (2 inches) for setting, the boiler maker to get five-eighths and the helper three-eighths, all to be paid for after the boiler passed the shop test. Now, this would look reasonable to an ordinary man not conversant with the trade, but it was quite contrary to the old conditions of working. In the first place, they had set a limit upon the amount you should earn, and should you go beyond that you got a cut in price for your next job. The other evil was the shop test; it being a very easy matter to put in a set of flues that will pass the shop test but will not pass the test of time. The life of these flues, put in by the piece-work system, averaged six months, while the same engines working under the same conditions, when the flues were installed by day work, lasted from two to three years. (These facts can be verified at any time.)

Now, take the premium system, as used by one of our locomotive works. The time allowance for a 2-inch flue is 22/100 of an hour, or at the rate of about four flues per hour, and I have seen the same piece setter putting them in at the rate of six per hour by day work. Who is the gainer in this case? This man was an expert flue setter, and an honest man, and would not slight his work for anything. Here, again, conditions were good, flue holes were carefully cut, so that there was no variation in any of the holes. Holes in a round head were given 1/64 inch clearance, and fire-box flue sheet drilled for 1/16-inch copper ferrules, which when slightly rolled admitted the flue with a few light taps with the steering bar.

Take riveting, both hydraulic and hand work, also chipping and calking, under the same system, the chances were that they turned out bad work, for this work was paid for just as soon as the job card was turned in at the time clock and the day workmen on the testing pit got the work of tightening up rivets and seams. In this shop I am well satisfied that piece work has been a failure, for although the men engaged in it can make more money than they did under the day-work system, they do so at the cost of becoming careless workmen and the manufacturer at the cost of his reputation.

Again, take the flanger who works piece work. He sees a chance to turn out more work by overheating his steel. What does he care, he is not going to use the boiler when finished; no, but he is going to get paid for every foot of flange turned, and the hotter he gets it the easier he turns it. It does not matter to him if it cracks while in the hands of the fitter-up, or if it lets go on the testing pit, as I have seen it happen. He falls back on the cry of bad steel. Yet there is no wonder that there are so many flange failures in our fire-boxes to-day, and they are put down to either too long or too short a turn in the flange, yet the true cause of the trouble is piece work and the greed of the flanger to get all there is in the job.

Now, I quite agree with Mr. John Cook, that to get the best results out of piece work in a boiler shop the men must be honest and skillful and willing to do piece work. And I also agree with another subscriber in the shipbuilding trade, that there is nothing that has caused so much labor trouble as piece work, and I may add that there is nothing on earth that has put so wide a gulf between employer and workman as this same piece work, and I for one trust that the day is not far distant when piece work will be a thing of the past, and the honest boiler maker be given a chance to show that he is a man and not a machine. Flex Ible.

The Element of Time

Life, like the mechanical business, is three-dimensioned except in the matter of time, of which the former is composed.

Time forms one of the materials, odd and otherwise, which the shop of to-day has to consider. From the recorder which punches us in to the penalties imposed upon late delivery of the goods under contract it is all essential.

Originally like many more materials it had less consideration than now. In the more leisured times, 'way back now, cast iron was cast iron; an immobile, rigid, unchanging material, but since the development of the planetary conception of the atoms of matter constantly in motion one is less sure. Certain it is that release of skin tension by machinery causes alteration in shape, and time is utilized as the tool to allow the material to assume approximately final form.

All materials flow to a greater or less extent under stress. Two materials, lead and bitumen, seem more fluid than most, since under no stress but their own weight they will change considerably in form. Also by suitable heat treatment we can make cast iron grow in volume.

Fatigue in ductile metals, aptly illustrated by the crystalization under repeated stress of wrought iron, can be removed by adequate periods of rest. There is a common instance in the case of the fine edge of a razor. Annealing is simply a mode of making this test expeditious. It has been stated as a truism that, given 1,000 years, a cutting tool of hardened steel would have lost in that period the internal stresses and molecular structure set up by hardening, and would resume its former soft state.

We humans are so constituted that the time element is necessary to get really good, new or improved ideas through to our brains.

In fact, if the idea be really too good and too new, the probability is that one lifetime is insufficient to spend in the missionary enterprises necessary to bring the new scheme or idea to fruition. Advertisement is the means usually chosen to habituate mankind in the mass to the utility of a new idea. It is really surprising how much repetition is essential in advertisements to make good the marketing of a really good idea. On the other hand, the simple reiteration of a single phrase repeated often enough has made success for quite ordinary goods.

A commercial traveler with a new line of goods may be considered as doing missionary enterprise, necessary to overcome the innate conservatism of the human mind.

Considering the efforts we all make to shorten time on operations, it may seem quaint that occasionally to lengthen the time required results in a saving; but the following instance bears that lesson:

Ash shovel handles are crooked by bending after prolonged soaking in boiling water by being violently thrust into half moulds of cast iron, each pair of moulds resembling a core-box with dowels. The handles with the boxes still on are taken off the machine and laid aside for twenty-four hours before the boxes are knocked off. Using this process, if the bending is severe (the average user prefers considerable crook) quite 25 to 30 percent of the quantity bent are wasters, breaking badly just at the extreme change of curvature.

Another and older process consisted in screwing the handle between formers, allowing the handles to stand in the racks a similar period.

Both these methods seemed to me faulty, in that time as an element in the equation seems not to have been duly considered. To me it appeared that the more slowly (in reason) the process was performed, the more chance the fibers of the wood had to slide over one another.

Some experiments were made with this end in view, and by using the rack process, setting up the handles in pairs, the percentage of wasters was lessened. During the screwing down of the racks the handles were kept standing immersed in boiling water. Setting thirty-six handles in pairs in a rack with bevel wheels to screw for each pair, and gearing same with a common shaft and ratchet feed, time could be varied as desired from ten minutes to one hour. Certainly the number of racks had to be increased, but the screws required no more labor. In this wise a cheaper grade of handle was made use of with a lessened percentage of wasters, and vindicated my theory that time can even be lengthened when occasion serves. *Festina lentè* (hasten slowly) is worth consideration as a motto. Progress may be hurried and breathless, but its general direction may be far from straight.

Reflective thought can never be a hurried process. Leisure to reflect is a necessity, not a luxury, even when using the most modern methods and processes. It is quite possible to get so busy that the fact is lost sight of that a small portion of grey matter is worth much physical effort. Meditation has gone out of practice, like the fasting which in mediæval times accompanied it, but the former has a definite value all the same.

To be in front of one's age and environment by a few hours spells success, but to be too far in front is, if anything, worse than to be a little behind.

Progress in mechanical things may be considered as an ascending helix. Not necessarily as a smooth curve, but an ascension with saw-tooth stairs, each of which is subdivided again into lesser teeth. The same problems come round for solution in cycles. In the interim between cycle and cycle fresh developments in materials and processes at other points render the previously insoluble possible.

It is all a question of time, yet the fact remains that each thing considered superseded and out of date remains a utility, though in a more limited sense. There are still sailing ships afloat which accept lower freights than a steamer can afford to. There are still simple engine lathes doing profitable work in spite of automatics. There are still all-around mechanics required to exercise an all-around craft despite specialized operators. The steam shovel has not put the man of pick and shovel out of business, nor the locomotive ousted the canal barge. Each has its particular sphere and time governs all.

London, England. A. L. HAAS.

Laying Out Irregular Cones

A work which often occurs in the pattern shops is to lay out irregular cones, as shown in Figs. 1 and 2. Usually this is done by triangulation. In the following, however, the writer will give another method for developing these cones, a method that gives a true pattern, a pattern on which every line is correct if it is carefully made.

Firstly, the plan and the elevation of the cone must usually be drawn as in Figs. 1 and 2. Now divide both circles, the large and the small, in Fig. 1, into a number of equal spaces, both circles having the same number; for instance, from 1 to 7 and *a* to *g*, respectively. Then project these points from

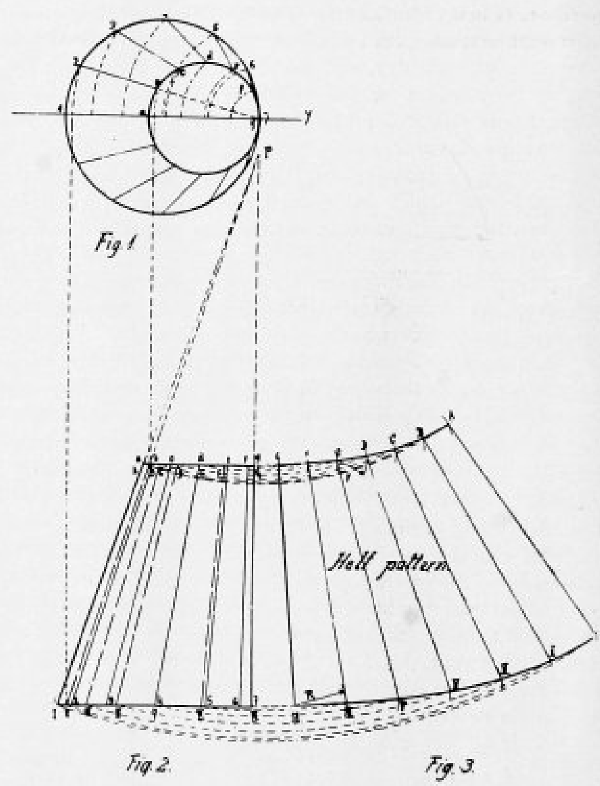


Fig. 1 to Fig. 2, and in both figures draw the lines 1-*a*, 2-*b*, 3-*c*, and so on. This line is intersecting another in the points 7 or *g* in Fig. 1, or in the point *P* in Fig. 2. Using 7 in Fig. 1 as a center, draw circles through the points 1-6 and *a*-*f*, all circles intersecting the line *X*-*Y*. Project these points to Fig. 2, as shown at the points 2 and 6, and thus locating the points *I*, *II*......*VII* and *A*, *B*......*G*. Drawing lines through *II* and *B*, *III* and *C*, *IV* and *E*, etc., you find that these lines are intersecting in the point *P*.

Now use *P* in Fig. 2 as a center, and draw circles through the points *I*, *II*, *III*......*VII*, and other circles through the points *A*, *B*, *C*......*G*. Now draw a line *G*-*VII* in Fig. 3. This line must also go through the point *P*.

Use *G* in Fig. 3 as a center and draw a circle with *r* as radius, intersecting the circles going through *F* in Fig. 2, thus locating the point *F* in Fig. 3. Now use *F* in Fig. 3 as a center and continue the process. Thus all the points from *A* to *G* in Fig. 3 will be located. The radius *r* is equal to one division of the small circle in Fig. 1, and is therefore equal to *a*-*b* or *b*-*c*.

Starting at the point *VII*, and using *R* as a radius, the points *VII-I* will be located. *R* is equal to one division of the large circle in Fig. 1, and therefore equal to 1-2 or 2-3. Fig. 3 gives the half pattern of the cone in which only rolling lines are used.

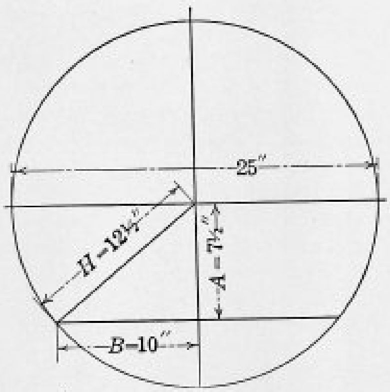
This above method is for use where the ends of the cones are circles. How to obtain the layout if the ends are ellipses or other figures will be explained in another article.

Graz, Austria. JOHN JASHKY.

Explanation for Layerouts

There are two rules for ascertaining lengths of lines much used by layerouts, and as I have never seen them fully explained in print, I think a little light as to their obtainment should lessen the vale of profundity that generally surrounds most formulæ, as well as diminish the tax on the memory, for when one knows why he usually knows how.

The fundamental basis of each rule lies in the known fact that the square of the base of any right triangle, plus the square of its height, equals the square of the hypotenuse. The first rule to be dealt with is that one which requires the finding



SKETCH FOR RULE I.

of the length of a line or chord of a circle a given distance from the center, the radius being known. This is just an application of the previously-mentioned fact. The hypotenuse is the radius, the height is the given distance from the center, and so the base, or half the required length, is found by subtracting the height, or given distance squared, from the radius squared and then abstracting the square root of the result. Then our rule is:

Let H = hypotenuse or radius.
A = height or given distance from center.
B = base or one-half the required length.

$$\sqrt{H^2 - A^2} = B.$$

The sketch with an example will perhaps make things clear.

Example: Find the length of a chord that is 7½ inches from the center line, the diameter of circle being 25 inches.

Observing our formula we have:

$$\text{Diameter} = 25 \text{ and radius} = 12\tfrac{1}{2}.$$
$$\sqrt{(12.5 \times 12.5) - (7.5 \times 7.5)} = B.$$
$$12.5 \times 12.5 = 156.25 = \text{square of } H.$$
$$7.5 \times 7.5 = 56.25 = \text{square of } A.$$
$$156.25 - 56.25 = 100.$$
$$\sqrt{100} = 10 = \text{one-half of chord, or } B.$$
$$10 \times 2 = 20 = \text{length of chord.}$$

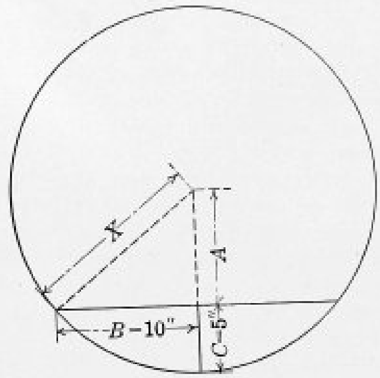
The second rule (to find the radius of an arc when the lengths of chord and versed sine are known) can be solved by two formulæ, both being equivalent algebraic expressions. In order to understand the derivation of this rule, an elementary knowledge of algebra is essential. In order to have one rule prove the other the same dimensions will be used, *i. e.*, the dimensions used in Rule No. 1 will be taken, presuming the radius to be unknown.

The two formulæ for the second rule are

$$\frac{B^2 + C^2}{2C} \text{ and } \frac{\frac{B^2}{C} + C}{2}.$$

Let B = one-half of chord.
C = versed sine.

A study of an example and the sketch for Rule No. 2 should make the reason of the formulæ plain.



SKETCH FOR RULE II.

x = hypotenuse or radius.
B = base, or one-half of chord, or 10.
A = height, or $x - C$, or $x - 5$.
C = versed sine, or 5.

The known fact is $x^2 = A^2 + B^2$.

By algebra we have

$$x^2 = (10)^2 + (x - 5)^2.$$
$$x^2 = 100 + x^2 - 10\,x + 25.$$
$$x^2 - x^2 + 10\,x = 100 + 25.$$
$$10\,x = 125.$$
$$x = 12.5 = \text{radius.}$$

Substituting letters for figures we arrive at the formula, hence:

$$x^2 = B^2 + A^2.$$
$$x^2 = B^2 + (x - C)^2.$$
$$x^2 = B^2 + x^2 - 2\,C\,x + C^2.$$
$$x^2 - x^2 + 2\,C\,x = B^2 + C^2.$$
$$2\,C\,x = B^2 + C^2.$$
$$x = \frac{B^2 + C^2}{2\,C}.$$

Substituting figures in the formula we have

$$\frac{B^2 + C^2}{2\,C} = \frac{(10 \times 10) + (5 \times 5)}{2 \times 5} = \frac{100 + 25}{10} = 12.5 \text{ radius.}$$

$$\frac{\frac{B^2}{C} + C}{2} = \frac{\frac{10 \times 10}{5} + 5}{2} = \frac{20 + 5}{2} = 12.5 \text{ radius.}$$

Honolulu, H. I. P. W. McDONOUGH.

BOILER INSPECTORS' MEETING.—At a meeting of New York boiler inspectors in the Engineering Societies building, New York, Nov. 29, a very instructive paper was read by Mr. C. L. Huston, of the Lukens Iron & Steel Company, on steel.

Fundamental Misconceptions

The design of a new machine or device of an experimental or untried character may be considered as a step on the road of mechanical evolution. Some things never evolve greatly beyond their first fundamental conception, minor matters of detail, trifling in character compared with the first conception, alone are further solved. This being where the first idea is practical and elemental.

There are some things in existence—the potters' wheel, for example—where the progress of all the ages has changed nothing material.

The two main issues resulting from the evolution theory are the survival of the fittest, and that the iron heel of necessity was a prime essential for ultimate divergence of type. Both of these laws apply to progress along mechanical lines to-day. Advertisement will not sell superseded goods, nor will it sell an article whose want has not been felt. Two functions of all sales propaganda are to create a desire and to keep the goods in the window.

Association, environment and training shape the individual, but only so far as he will sink his individuality. If this be strong the outside influences only warp or twist, but do not stullify the original bent. Any system of education not giving play to individual effort is based on a misconception of its legitimate functions. Discipline, in a training sense, is not the instinctive movement at the word of command, but rather a reasonable tolerance between defined limits of individual effort. Some knowledge has to be acquired by all; willingly under proper guidance it is easy, but its acquaintance has to be made sooner or later. One teacher's phrase to his pupils was that only fools learn from experience, people with more sense learn from the experience of others. This cannot be endorsed in its entirety, but, like the majority of English proverbs, it has a limited sense in which it is true. No one can be taught in the sense that the responsibility for failure to acquire can be altogether laid at the teacher's door. All knowledge is self-acquired. All that tuition can do is to present information in a readily grasped form, and to correct mistaken notions as they arise. The function of tuition and training is to keep effort along a road of reasonable width rather than to waste energy over too wide an area.

A ratchet-brace was placed on the market some time ago of an improved form, and to the surprise of others beside the inventor proved a non-starter. It consisted of practically an automobile differential on a small scale, and the object achieved was to make the drill cut at both motions of the handle. As a piece of mechanism it was ingenious and successful, as a commercial proposition it was a bad egg. The misconception here was evident. In use the operator in one direction of motion would be working in an unnatural position. Using an ordinary brace the momentary rest given in one direction has a definite value. The case of an oar in a rowboat comes to mind; it would be clearly impossible to row on both stroke and recovery. Drilling with an ordinary brace proved faster than with the new.

The patent office is the graveyard of fundamental misconceptions. Fully 75 percent of the patents granted or applied for are based on misconceptions, and can be riddled from a commonsense mechanical standpoint.

In any suggested improvement it is the first prime duty to closely examine the conception on which it is based. Analogy is here a great help to reasoning, though this possesses dangers obvious to the logician. It is impossible to build on clear air. A superstructure, perfect mechanically, may be built up upon insecure foundation. No idea comes as an inspiration or bolt from the blue, though such a feeling is experienced sometimes. Thought along one particular line is stored together with already received impressions, and daylight is reached after long cogitation. The ultimate outcome is built on the past in every sense as truly as that a building is formed brick by brick. The difficulty of finding a super-electricity is due to the fact that the starting platform has not yet been erected to carry mental effort along a totally new path.

Gasolene has many recent applications. Probably its least successful application until recently was its use for pumping. The misconception was that arising from its success to drive cars and neglecting to study the conditions under which an automobile operates. Pumping is collar work all the time. An automobile only uses full power for limited periods with considerable alternating periods of half or less power. The use of an engine designed for cars for pumping purposes, allowing a margin of 10 percent below rated capacity, proved a dismal failure.

A misconception as to mental processes, rather widespread, is the popular use of the word concentration. Ultimate success is pictured to us if we will concentrate our minds. The result of the average man's attempts to do this is simple disgust at the lamentable failure of his mental equipment. It is impossible to concentrate the attention on a particular idea for more than a few seconds at a time. This is a human limitation set by Nature and cannot be altered. Like the flicker of the eyelid the mind must travel on. The power of concentration consists in the immediate return to the original thought.

In the question of difficult design it is folly to brood too long on the one difficult point. It should be attacked again and again after rest periods of other work; only so can the baffling point just out of reach be overcome.

A maxim worth remembrance is that the obvious is usually wrong. So true is this that the most obvious excuse made by a delinquent is instinctively distrusted by his superior. In mechanical work it is a truism to beware of the obvious easy path. No solution worth anything is ever obvious and plain. It is the pursuit of the obvious that has put many concerns out of business.

Misconceptions may arise due to the limitations of individual speech. Resentment and a feeling of injury on the part of workmen may be sometimes traced to their want of explicit speech. It requires some mental agility to follow an involved explanation, to bridge the obvious gaps, to grasp the half-plain meaning, to use patience and try to fathom the underlying truth. A works manager, otherwise capable, can easily lose ground in this way by shaking the confidence of his men. One of the most capable mechanics known to me has the attitude of a convicted dog stealer; to deal with him without prejudice would puzzle an angel; yet after years of contact it has proved an unfortunate mannerism, nothing more. Misconceptions due to prejudice arise; we are all biased in some measure. It takes continual effort to prevent the innate conservatism within us all from landing us in a groove from which the lifting may be painful. Where the work under our charge seems running smooth with no complexities anywhere is the period of danger. Sure as eggs are eggs the present is the lull before the storm, and difficulties will presently bristle all along the path. A reasonable amount of trouble keeps us alert, and seems to insure against trouble of a larger order. Yet no change should be made without reasonable cause, and if important not without consultation. It makes the road more plain to talk matters out even if the listener cannot help.

A. L. H.

VANCE BOILER WORKS DESTROYED.—The plant of the Vance Boiler Works, Geneva, N. Y., was totally destroyed by fire on Dec. 1. The loss is partly covered by insurance. It is reported that the company will rebuild at once, as there are a large number of orders on hand for boilers and tank work which must be completed as soon as possible.

Selected Boiler Patents

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

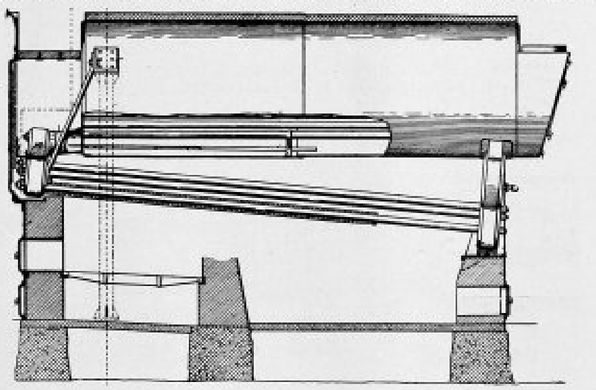
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

1,035,741. SMOKE CONSUMER. MILTON EUGENE REED, OF ANNAPOLIS, MD., ASSIGNOR TO LOCOMOTIVE EQUIPMENT COMPANY, A CORPORATION OF MAINE.

Claim 3.—In a water-tube boiler setting, having a fire-box and tubes, a roof for the fire-box composed of tiles resting on and between the tubes of one of the lower rows, some of the tiles being hollowed to form air passages and perforated to permit the escape of the air, and means for supplying air to the passages consisting of a supply conduit extending across the tubes and roof, and having nipples, the tiles being apertured to receive the nipples so that they communicate one with each air passage. Six claims.

1,035,607. STEAM BOILER. CHARLES KROESCHELL, OF CHICAGO, ILL., ASSIGNOR TO KROESCHELL BROS. CO., OF CHICAGO, ILL., A CORPORATION OF ILLINOIS.

Claim 1.—A boiler structure comprising, in combination, a housing containing a fire chamber, a fire-tube boiler having a depending manifold at its rear end by which it is supported on the rear housing-wall,



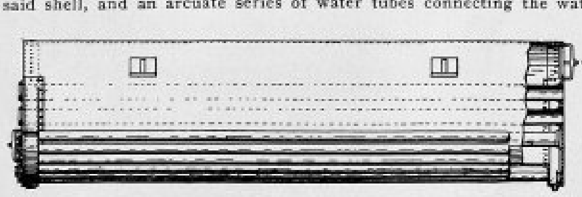
pillars supporting said boiler at its forward end, whereby it is unsupported except at its rear end by said housing, a manifold at the forward end of and communicating with said boiler and supported thereon to be carried by the pillars, and water-tubes extending over said chamber and connecting the manifolds. Five claims.

1,036,539. STEAM-GAGE HOLDER. GEORGE E. BAILIE, OF DENVER, COL.

Claim 2.—A gage holder, comprising a support, an arm vertically adjustable on the support, its upper extremity being equipped with a forwardly-extending member provided with a depending retaining spring, and rigid clips acting upon the gage below the spring in supporting relation. Five claims.

1,037,776. STEAM BOILER. MICHAEL F. KENNEN, OF NEWPORT, KY.

Claim.—In a horizontal fire-tube boiler, a cylindrical boiler shell, a downwardly and laterally spread depending water leg at each end of said shell having an inner arcuate flange of length greater than a semicircle and extending at each side above the axial plane of and riveted to said shell, and an arcuate series of water tubes connecting the water



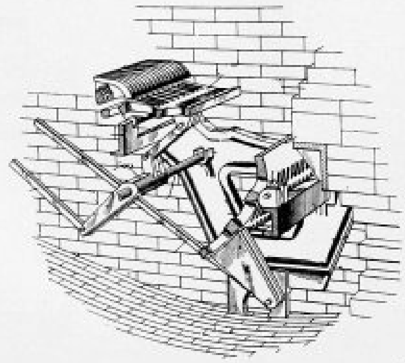
legs, said series having a lateral spread greater than the diameter of said shell, and said water legs having upward and inward extending converging end walls engaging and riveted to the upper lateral portions of said shell, whereby the rivet connections between the water legs and the boiler are relieved of the strain of support of the water legs and of the series of water tubes. One claim.

1,037,422. SOOT CLEANER FOR STEAM BOILERS. WILLIAM J. BRADLEY, OF TROY, N. Y., ASSIGNOR TO MONARCH STEAM BLOWER COMPANY, OF TROY, N. Y., A CORPORATION.

Claim 1.—In a device in combination, a box provided with a bottom-opening; means for supplying to said box fluid under pressure; a pipe rotatively mounted in said opening, said pipe and box having co-operating ball-and-socket bearing members whereby said pipe is suspended from said box through the bottom opening therein; means for rotating said pipe; and nozzles carried by said pipe. Six claims.

1,037,715. FURNACE. FRANK C. ARMSTEAD, OF PITTSBURG, PA., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE COLONIAL TRUST COMPANY, TRUSTEE, OF PITTSBURG, PA., A CORPORATION OF PENNSYLVANIA.

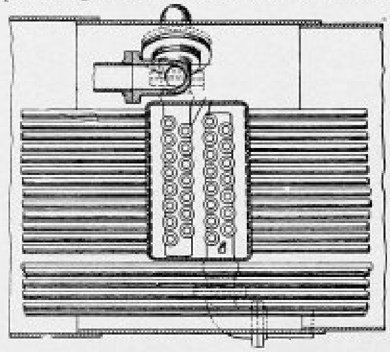
Claim 2.—A furnace having a bridge wall with an overhanging portion, a series of grate bars forming an inclined grate terminating in front of the overhanging portion, a dumping grate at the foot of the inclined grate and having a rearwardly extending upwardly curved lip terminating at the angle of intersection of the inner and horizontal



faces of the overhanging portion, said dumping grate being pivoted between its front and rear ends whereby the lip on the grate in rear of its pivoted portion will swing above and away from the intersection of the inner and horizontal faces to free the front face of the bridge wall of clinkers and permit them to drop down between the dumping grate and the overhanging portion. Two claims.

1,037,313. STEAM-SUPERHEATING APPARATUS FOR LOCOMOTIVES. JOHN PRIMROSE, OF NEW YORK, N. Y.

Claim 4.—In a steam boiler, the combination with discontinuous fire-tubes, of a superheating chamber located between the sections of said



tubes, the superheating chamber comprising a substantially rectangular body portion projecting at its opposite ends through opposite sides of the boiler shell. Eleven claims.

1,037,245. BOILER-TUBE CLEANER. RICHARD W. HAMANN, OF ST. LOUIS, MO., ASSIGNOR TO EUGENE J. FEINER, OF ST. LOUIS, MO.

Claim 1.—In combination with a water tube of a boiler, a cleaning nozzle disposed lengthwise of said tube, and means for securing the nozzle to and parallel with the tube. Six claims.

1,037,240. BOILER FEED-WATER REGULATOR. HAROLD K. GOWDY, OF PITTSBURG, PA.

Claim 1.—In a boiler feed regulator, a feed valve, a diaphragm to which the valve is connected, a chamber containing the diaphragm, water legs of substantially equal height communicating with said chamber at opposite sides of the diaphragm, one of said legs having a constant height of water therein to act upon the diaphragm to hold the valve open, and the other leg being normally empty, a passage connecting the other of said legs with the water space of the boiler and arranged to be sealed by the rise of water in the boiler, and auxiliary means connected to the valve and tending to close it, and a return or discharge connection between the normally empty leg and the water space of the boiler. Three claims.

1,038,707. SPARK-ARRESTER. WALLACE C. YEOMANS, OF PE ELL, WASH.

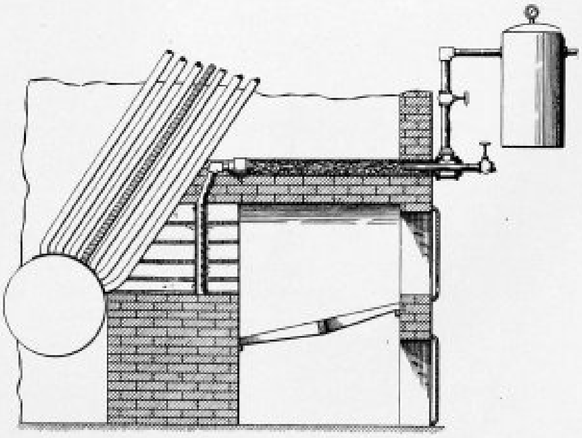
Claim 1.—In a spark arrester, the combination with a smokestack, a shell formed of two reversely arranged frusto-conical sections secured to the top of said stack, the maximum diameter of said shell being intermediate its height, two superposed series of blades, each of said series of blades being inclined similarly to the respectively adjacent section affording an annular space betwen said blades and shell, and a plurality of vanes arranged axially of said shell to effect a whirling motion to smoke passing upwardly through the shell. Four claims.

1,039,205. SMOKE CONSUMER. ROBERT G. SPEER, OF ST. LOUIS, MO.

Claim 1.—The combination with a boiler and its furnace, of pipes leading from the breeching to the fire-box of the furnace, a plurality of branch pipes leading from the first-mentioned pipes through the side and front walls of the fire-box, thereby substantially surrounding the same, means within the breeching for heating atmospheric air and discharging the same when heated into the inlet ends of the first-mentioned pipes, and jet tubes arranged in the branch pipes and in the inlet ends of the first-mentioned pipes for producing a forced circulation and mixture of the products of combustion and air through the first-mentioned pipes and discharging such mixture into the fire-box. Three claims.

1,038,677. FURNACE. JAMES D. STEWART, OF CHICAGO, ILL., ASSIGNOR OF ONE-THIRD TO OSCAR O. LAUDIG AND ONE-THIRD TO WILLIAM F. DICKSON, OF CHICAGO, ILL.

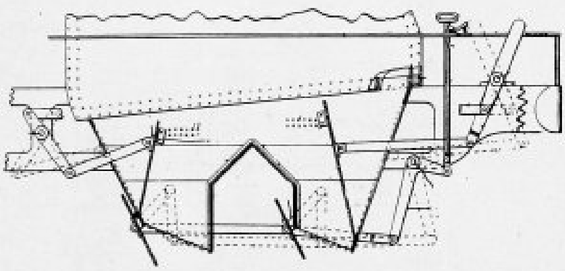
Claim 1.—A steam boiler furnace having an arch above the fire-box, and a bridge wall, a set of horizontal fire-brick flues in the space between the bridge-wall and the arch, and a vertical cross passage through



said flues, and a series of mixing tubes exposed to the heat of the furnace, and provided with perforated discharge pipes located in said passage. Six claims.

1,038,987. LOCOMOTIVE ASH-PAN. JOSEPH A. SWARTZ, OF FORT WAYNE, IND.

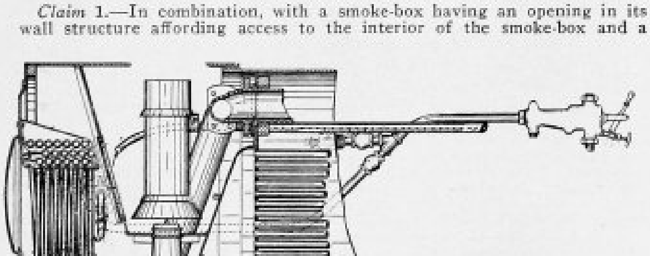
Claim 1.—A locomotive ash-pan having a transverse arch intermediate its ends, the bottom of said pan being open to provide discharge orifices at the sides of said arch, means for normally closing said discharge



orifices, means for actuating said closing means, and means arranged within the pan above said discharge orifices and co-operating with the transverse arch to exert lateral pressure on the contents thereof in the plane of said arch and at right angles thereto. Six claims.

1,039,000. FEED-WATER HEATER. DAVID T. WILLIAMS, OF PATERSON, N. J., ASSIGNOR OF ONE-HALF TO FRANK L. CONNABLE, OF WILMINGTON, DEL.

Claim 1.—In combination, with a smoke-box having an opening in its wall structure affording access to the interior of the smoke-box and a



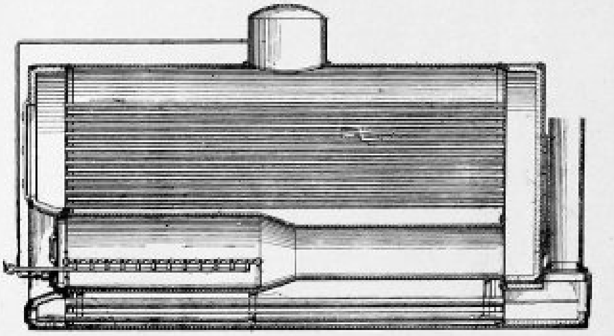
removable closure member for said opening, a feed-water heater carried by said closure member. Six claims.

1,039,273. APPARATUS FOR CONTROLLING THE ADMISSION OF STEAM TO THE AUXILIARY BLAST OF BOILER FURNACES. GUSTAV DE GRAHL, OF ZEHLENDORF, NEAR BERLIN, GERMANY.

Claim 2.—In means for regulating the supply of steam to the auxiliary blast of locomotive boiler furnaces, the combination of a valve-box having a steam admission port at one end thereof connected to the boiler, an auxiliary blast port leading to the auxiliary blast normally in open relation with the steam-admission port, and a steam port at the other end of the valve-box connected to the steam chest; a closure member movable in the valve-box for shutting off the auxiliary blast port from the steam-portadmission port, the admission port end of the closure member being smaller than the other end, throttling means in the valve-box between the steam port and the latter end of the closure member, said closure member having a duct connecting the end of the valve-box in front of the smaller end with the end thereof behind the larger end of the closure member. Seven claims.

1,039,256. STEAM GENERATOR. HARRY CLIFTON, OF CANAL DOVER, OHIO.

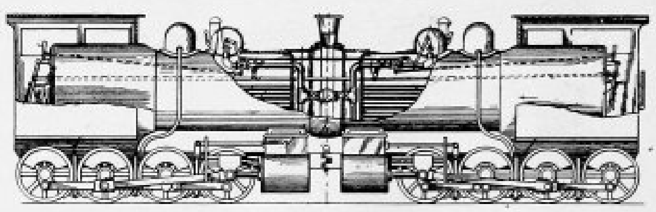
Claim.—An internally fired boiler, comprising a shell, a pair of parallel furnace flues leading into a rear combustion chamber, and means for supporting said flues, said means consisting of a plurality of frames each comprising spaced apart curved portions conforming to and bearing



beneath the furnace flues and connected centrally by a horizontal portion, said curved portions each terminating in a horizontal extension bearing against the inner face of the shell, downwardly extending vertical portions carried by said curved portion, and curved bracket members connecting said horizontal and vertical extensions and conforming with and adapted to bear against the inner face of the shell. One claim.

1,039,304. LOCOMOTIVE. FRANK MARTIN, OF RENOVA, PA., ASSIGNOR OF ONE-HALF TO MORRIS DI BELLA, OF RENOVA, PA.

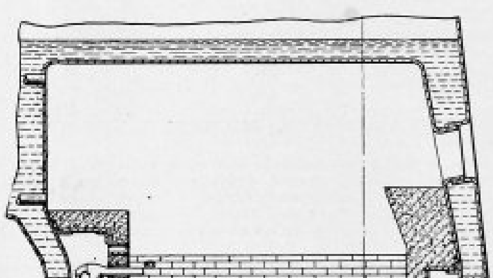
Claim 1.—In a locomotive, confronting boilers each having a smoke-box at its end terminating in a flared flange, a common ring of curvili-



near cros section conforming to the contour of both flanges and securing the boilers for relative movement, a smokestack carried by said ring, and a wheeled frame supporting said boilers. Four claims.

1,039,570. OIL-BURNING STEAM BOILER. WILLIAM J. McLEAN AND JOHN L. McCAULEY, OF BELLINGHAM, WASH.

Claim 1.—In a structure of the character set forth, the combination with a furnace having an air inlet and a burner for projecting a flame



into said furnace, of means for supplying air to the inlet comprising a conduit having opposite intake openings, and a bottom that inclines downwardly in opposite directions from an intermediate point toward said intake openings. Eight claims.

1,041,212. OPENING DEVICE FOR FURNACE-DOORS. JOHN WHEELER, OF CRIPPLE CREEK, COL.

Claim.—A means for opening furnace doors, comprising a vertically movable actuating rod, part of which is rectangular in cross section and provided with screw threads below said rectangular portion, said rod constituting the lower hinge pin of the door, a bracket extending from the furnace in threaded engagement with said screw-threaded rod, said rod having a leaf extending from the door of the furnace, said leaf having a bore rectangular in cross section extending therethrough and in sliding engagement with the rectangular portion of the rod, a hinge connection between the furnace and door having its pivotal point in axial alinement with said rod, a lever one end of which is positioned below said rod, and a pedal resting upon the opposite end of said lever whereby stepping on said pedal will raise and rotate said rod, thereby opening the furnace door on its hinges. One claim.