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THE BOILER MAKER

VOL. VIII JANUARY, 1908 No. 1

ESTIMATING THE COST OF A RETURN TUBE BOILER.

BY F. C. DOUGLAS WILKES.

In writing this article the author is well aware that there are no hard and fast rules that can be laid down for figuring out the cost of a boiler. The price of labor will vary considerably in different manufacturing plants. Then, on account of freight rates, etc., one firm will be able to lay down the material much more cheaply than its competitor, who may be situated at a greater distance from the source of supply. Again, the facilities for handling the work in the shop are hardly ever the same in any two plants, costing much in some and little in others. The labor in one shop may be of better quality than in others, and so on, all of which goes to show that, as has been stated, no hard and fast rules can be laid down in estimating the cost of a boiler before any work has been done on it.

The object of this article, therefore, is to show how the cost of a boiler is estimated in instances which have come under the writer's observation, and perhaps it may serve as a guide to those whose duty it is to figure on similar boilers or any other type of boiler, tank or stack.

It is obvious that at the outset one should know the different stages of manufacture, the men employed and the aproximate time it takes to complete each stage. The following table gives the various stages gone through; the number of men employed and the average wage of each one in the particular shop in which the boiler we are about to consider is to be built:

Stage.	Men Employed.	Wage Per Hour.
Laying out	1 layer-out	$0.40
	1 assistant	.20
Shearing, Punching, Rolling — each	1 handy man	.18
	2 helpers	.16 each
Planing	1 handy man	.18
	1 helper	.16
Flanging	1 flanger	.30
	2 helpers	.16 each
Cutting tube holes	1 handy man	.18
Riveting (bull machine)	1 riveter	.18
	2 helpers	.16 each
Riveting (air machine)	1 riveter	.22
	1 holder-on	.17
	1 rivet boy	.10
Making stays, crow-feet, etc.	1 blacksmith	.30
	1 hammer man	.18
Inserting stays	1 man	.25
	1 helper	.16
Inserting tubes	1 man	.25
	1 helper	.16
Calking	1 man	.20
Painting	1 painter	.22

In addition to the above must be added the cost of testing and shipping the boiler. The total cost of this for any size boiler can easily be covered by $10.00.

We will assume that we have had an inquiry from some person who desires a quotation on one horizontal return tubular boiler 72 inches diameter and 18 feet long, containing seventy-four 4-inch tubes, to be built for a working pressure of 125 pounds per square inch, and to be built "open for inspection" under the rules for the Inspection of Steam Boilers for British Columbia. The above rules have been chosen, as they are the stiffest and best defined of the Canadian rules for land or stationary boilers. It will be interesting to note the similarity of these rules with those of the British Board of Trade recently described in the pages of THE BOILER MAKER (Nos. 5, 6, 7, 8, Vol. VII).

The cost of a boiler will invariably depend upon the working pressure, because it is this pressure which will (under all inspection rules) determine the thickness of plate, the style of joint, etc. Therefore, first determine the thickness of plate and style of joint necessary for the boiler when the holes have all been punched full size before bending, which is, of course, the cheapest method. Now, the least expensive joint is an ordinary lap joint, so we will see what the least thickness of plate is which we may use with this joint, making it treble riveted.

According to the British Columbia laws:

"When cylindrical shells of boilers are made of the best material (either iron or steel) with all holes drilled in place, the plates afterwards taken apart and the burrs removed, and all longitudinal seams fitted with double-butt straps, each at least five-eighths the thickness of the plates they cover, the seams being double riveted with rivets having an allowance of not more than 75 percent over single shear, and having the circumferential seams constructed so that the percentage is at least one-half of that of the longitudinal seams and provided that the boiler has been open for inspection during the whole period of construction, then 4 may be used as a factor of safety.

"But when the above conditions have not been complied with the additions in the following scale must be added to the factor of safety according to the circumstances of each case:

".15—To be added if all holes are fair and good in the circumferential seams but punched before bending.

".3—To be added if all holes are fair and good in the longitudinal seams but punched before bending.

".07—To be added if double-butt straps are not added to the longitudinal seams and the said seams are lap and treble riveted."

According to our assumption then and the above rules, our factor of safety will be 4.52.

The next point we must consider is the pitch of the rivets, in order that we may figure the percentage strength of the joint. The British Columbia rule governing the pitch is exactly the same as that of the British Board of Trade to be found on page 218 July (1907) issue of THE BOILER MAKER. It depends upon the thickness of the plate as well as the style of joint. Thus we have one more assumption to make, viz.: the thickness of plate we should use with our boiler having a treble riveted lap joint.

Let us assume 7/16 inch to be the thickness of plate, and figure through to see if we will be allowed 125 pounds per square inch working pressure on the boiler. For the pitch we have $C \times T + 1\frac{5}{8} = P$ where

C = Constant from table (page 218, No. 7, Vol. VII.) = 3.47.
T = Thickness of plate.
P = Maximum pitch.

Substituting values we have

$$3.47 \times .4375 + 1\frac{5}{8} = 3.143, \text{ or } 3\frac{1}{8} \text{ inches.}$$

Using ¾-inch rivets in 13/16 holes, this value of P gives us in the formula for percentage strength of plate

$$\frac{(3.125 - .8125) \times 100}{3.125} = 74 \text{ percent.}$$

If this percentage is less than that of the rivet section it will be the one used in figuring the working pressure. To consider the rivet section, the British Columbia laws give us the following formula for finding the percentage strength:

$$\frac{100 \times A \times N \times Y \times C \times F}{4 \times Y' \times P \times T} = \text{percent,}$$

where A = area of rivet when driven (in square inches).
N = number of rivets in one pitch.
Y = 23 for steel plates and steel rivets.
C = 1 for lap joints and 1.75 for double-butt strap joints.
F = factor of safety.
Y' = 28 for steel plates and steel rivets.
P = pitch.
T = thickness of plates (in inches).

Substituting we have

$$\frac{100 \times .5184 \times 3 \times 23 \times 4.52}{4 \times 28 \times 3.125 \times .4375} = 105 \text{ percent.}$$

The British Columbia formula for finding the working pressure is

$$\frac{T_s \times r \times 2T}{D \times F} = B,$$

where T_s = tensile strength of plate.
r = smallest of percentages divided by 100.
T = thickness of plate in inches.
D = inside diameter of largest course in inches.
F = factor of safety.
B = working pressure.

Substituting we have

$$\frac{60{,}000 \times .74 \times .875}{72 \times 4.52} = 119 \text{ pounds per square inch.}$$

Therefore, 7/16-inch plate is too thin.

Trying ½-inch plate and following through as above we get the maximum pitch to be 3⅜ inches, percentage of plate 76, percentage of rivet section 85.6, and working pressure 140 pounds per square inch. Therefore, if we desire, we may use ½-inch plate and ¾-inch rivets with treble riveted lap joint.

Now, let us see what thickness of plate we could use with a double-butt strap treble riveted joint, in which case we would have two inside rows of rivets through both straps and plate, and the outside row through one strap (the inside one) and plate. Our factor of safety in this case would be 4 plus the following:

.3 to be added if holes are fair and good in the longitudinal seams but punched before bending.

.15 to be added if all holes are fair and good in the circumferential seams but punched before bending, making a total of 4.45.

In figuring the pitch for this style of joint the same formula is used as before, but the constant changes as will be seen from the third column of the table on page 218, July (1907) issue. This constant is 3.5, and not 4.63, as one might be led into thinking, by the fact that the joint is called "treble" riveted. The reason the constant is 3.5 and not 4.63 is because there are only *two* rows of rivets in *double* shear, hence to find the maximum pitch we treat the joint as though it were a double-riveted, double-butt strap joint, and omit every other rivet in the outer rows to make the percentage strength of the plate higher. If we extend the outer strap to take in these rows of rivets the large pitch would raise difficulties in calking the boiler, although the joint would be stronger through the rivet section.

Our pitch, therefore, becomes for the inner rows using 7/16-inch plate,

$$(3.5 \times .4375) + 1.625 = 3.156, \text{ or } 3\frac{1}{8} \text{ inches,}$$

making the pitch of the outer rows 6¼ inches.

Now, we have three percentages to find, viz.:

(1) The percentage strength of the plate, which will be that at the outer row of rivets.

(2) The percentage strength of the rivet section which will be that of the two inner rows added to that of the outer row.

(3) The combined percentage strength of plate and rivet section, which will be the percentage strength of plate at the inner rows added to that of the rivets of the outer row.

For (1), with ¾-inch rivets and 13/16-inch holes, we have

$$\frac{(6.25 - .8125) \times 100}{6.25} = 87 \text{ percent.}$$

For (2)

$$\frac{100 \times .5184 \times 2 \times 23 \times 1.75 \times 4.45}{4 \times 28 \times 3.125 \times .4375} + \frac{100 \times .5184 \times 1 \times 23 \times 1 \times 4.45}{4 \times 28 \times 6.25 \times .4375} =$$

$$121 + 17 = 138 \text{ percent.}$$

For (3)

$$\frac{(3.125 - .8125) \times 100}{3.125} + \frac{100 \times .5184 \times 1 \times 23 \times 1 \times 4.45}{4 \times 28 \times 6.25 \times .4375} =$$

$$74 + 17 = 91 \text{ percent.}$$

So by using the smallest of these percentages, 87, our allowable working pressure is

$$\frac{60{,}000 \times .87 \times .875}{72 \times 4.45} = 142.5 \text{ pounds per square inch.}$$

This is in excess of what we want, but if we use ⅜-inch plate we could get only 120 pounds, so we will use 7/16-inch plate if we decide on this style of joint.

We have, therefore, the option of using ½-inch plate and treble-riveted lap joints, or 7/16-inch plate with treble-riveted double-butt strap joints; so, to decide, we will figure out the cost of a shell made each way. Just here might be noted the cost prices, laid down at the factory, of the materials used in this boiler. They are

Flange steel, per 100 pounds...............	$2.10
Shell steel, per 100 pounds.................	2.00

Tubes (4 inches diameter), per foot........	$0.18
Stay iron, per 100 pounds..................	2.00
Cast iron, per 100 pounds..................	2.50
Rivets, per pound..........................	.03
Angle iron, per pound......................	.0225

COST OF LAP JOINTED SHELL.

First we will consider the lap jointed boiler, and start by finding the weight of plate to be used. For this style of joint the plates will be (allowing the finishing) large course, 107½ inches by 234¼ inches by ½ inch, and the small course 107½ inches by 231 inches by ½ inch. The weight of these will be:

$$\text{Large course } \frac{107.5 \times 234.25 \times 44^* \times 1}{144 \times 2} = 3{,}850$$

$$\text{Small course } \frac{107.5 \times 231 \times 44 \times 1}{144 \times 2} = 3{,}794$$

Total 7,644 lbs.

The cost price of this at 2 cents per pound equals $152.88. The first work done on the plates is, of course, laying them out. This, including the handling, ought to be done in six hours. Cost: layer-out at 40 cents equals $2.40 and assistant at 20 cents equals $1.20, total $3.60. Next in order comes the shearing of the plates. Including the handling this will take about three hours. Cost: one handy man at 18 cents equals $0.54, two helpers at 16 cents each equal $0.96, total $1.50. Then comes the punching. The number of holes to be punched will be:

114 in each girth seam, or in 4 seams............	456
190 in each longitudinal, or in 2 seams..........	380
Holes for stays, nozzles, brackets, etc., about.....	150
Total holes to be punched...................	986

The gang on this job should average 125 holes an hour, including handling. This will make the time for punching about eight hours. Cost: one handy man at 18 cents equals $1.44, two helpers at 16 cents each equal $2.56, total $4.00. Planing the plates will take about six hours. Cost: one handy man at 18 cents equals $1.08, one helper at 16 cents equals $0.96, total $2.04. Next, the rolling will consume about four or five hours. Cost: one handy man five hours at 18 cents equals $0.90, two helpers at 16 cents each equals $1.60, total $2.50.

In riveting up we will use the bull machine for the center girth seam and the longitudinal seams. Taking 114 rivets in the girth seam and 190 in the longitudinal seams we will have 304 rivets to drive. Having the plates properly fitted, the riveting gang should average a rivet a minute, taking five hours. Usually, though, the plates have to be "squeezed" and fitted into plate, holding bolts removed, etc., so it would be safe to add about four hours to cover this, making a total of nine hours. Cost: one riveter at 18 cents equals $1.62, two helpers at 16 cents each equals $2.88, total $4.50. Calking seams, five hours at 20 cents equals $1.00.

Summing up we have a total cost for the naked ½-inch shell, with treble-riveted lap joints, of $172.02.

COST OF BUTT JOINTED SHELL.

Considering the naked shell with the butt strap joint and 7/16-inch plate we have the large course, 107.5 inches by 228 inches by 7/16 inch, and the small course, 107.5 inches by 226 inches by 7/16 inch. The weight of these plates will be:

$$\text{Large course } \frac{107.5 \times 228 \times 44 \times 7}{144 \times 16} = 3{,}278$$

$$\text{Small course } \frac{107.5 \times 226 \times 44 \times 7}{144 \times 16} = 3{,}214$$

Total 6,492 lbs.

Cost price of this at 2 cents per pound equals $129.84. In this shell there are the butt straps to be considered. The outer ones will be 8½ inches by 107 inches by ⅜ inch, and the inside ones 14 inches by 107 inches by ⅜ inch, and the total weight 552 pounds. Cost price at 2 cents equals $11.04, making a total for the plate of $140.88.

The laying out of these plates would take longer than in the first case, on account of the extra rows of rivets and the butt straps. It should take about seven hours; cost $4.20. The shearing and planing would cost about 15 percent more than with the lap joint, which would amount to: shearing $1.73, planing $2.35. Punching—we have the same number of holes in the girth seams but less in the longitudinal seams, and also the holes in the butt straps.

Holes in girth seams............................	456
Holes in longitudinal seams, 158 in each seam.....	316
Holes for stays, nozzles, brackets, etc............	150
Total in shell..............................	922
Holes in butt straps............................	316

Taking the rate for the holes in the shell the same as before, viz.: 125 per hour, the time consumed for the plates would be about 7½ hours; cost $3.75. As the butt straps are small and more easily handled the holes in them would be punched at the rate of about 200 per hour. Time for 316 holes being 1.58 hours; say 1½; cost $0.75. The total cost for punching therefore equals $4.50. Rolling the plates would be the same as with the lap joint; viz.: $2.50. Rolling or bending butt straps would take three hours; cost $1.50. Riveting the shell on the bull machine will cost about 20 percent more than the lap joint, on account of the extra fitting necessitated by the butt straps, making the cost of riveting $5.40. Calking would also take longer, say six hours; cost $1.20.

Summing up the total cost for the naked shell with butt straps it is found to amount to $164.26. Thus we see that the smaller first cost of the thinner plate used with a butt strap joint is more than enough to offset the more expensive style of joint, showing us that it will be cheaper to use the thin plate and expensive joint than to use the cheaper joint and thicker plate. Also, we get a much lower factor of safety with the butt straps, and a saving in weight of about 600 pounds with a consequent saving in freight rates on the plate coming in and the boiler going out, which will amount to quite an item if the distances are at all great.

To the casual observer, all the detailed figuring, as above, would appear superfluous and apart from the main subject of this article. The reason it has been set down in full here is to give the layman an idea of the differences in the two modes of manufacture. Usually all this figuring of the weight of the shell of boilers, according to the pressure, need be carried through only once for each size of boiler and for two or three pressures. These results should be tabulated and kept on record for future rapid reference.

COST OF COMPLETED BOILER.

Having decided on the butt joint and 7/16-inch plate, we will now carry through the complete estimate for our boiler. The diameter of the larger head being 78¾ inches, the weight is (using ½-inch plate) 745 pounds, and the small head being 77¾ inches diameter, weighs 726 pounds, total weight of heads 1,471 pounds; cost of material at 2.1 cents per pound equals $30.89. Laying out the heads would take about four hours, and from our wage table cost $2.40. The flanging of the heads is usually done before the bead is laid out for the tubes, and

* Forty-four pounds being taken as the weight of 1 square foot of steel 1 inch thick.

in this instance was done by hand. This would take, for both heads, all of fifteen hours, costing: one flanger at 30 cents $4.50, two helpers at 16 cents each $4.80, or a total of $9.30. Punching the holes, of which there are 316 in the two heads, made up as follows: 114 holes in each circumference and 44 holes for stays, would take about three hours, and cost: one handy man $0.54, two helpers $0.96, total $1.50.

Next, the heads go to the drill to have the tube holes cut. The centers are first drilled out, taking about four minutes per hole, and as there are 148 holes this would consume about ten hours; cost: one handy man at 18 cents $1.80. Cutting the full size hole would take ten minutes per hole, or 24½ hours, and cost $4.41. As there is a manhole in one end, this must be reinforced with a wrought iron ring shrunk on and then planed square. Making the ring and shrinking it on will take a blacksmith and a hammer man all of five hours and cost $2.40. Planing will take about three hours, and adding one hour for handling, make four hours; cost for one machinist at 25 cents per hour equals $1.00.

In riveting the heads to the shell, the bull machine is used for one head, and will take, with fitting, etc., two hours, costing $0.68. The other head must be riveted up by air hammers. There are 114 rivets to drive, and the air gang should drive one every three minutes; total 5.7 hours or six to cover time taken in fitting, etc.; cost: one riveter $1.32, one holder-on $1.02, one rivet boy 60 cents; total $2.94.

The shell being completed and the heads in place we now come to the stays. There are forty-four of these, and they are made by the blacksmith. First of all he makes the crowfeet, and figuring that he will do one in four heats, or about fifty minutes, the total time will be about thirty-seven hours; cost: one smith at 30 cents equals $11.10, one hammer man at 18 cents equals $6.66; total $17.76. Forging the palms of the stays and welding the crowfeet to them will take about an hour each, totaling forty-four hours and costing $21.12. In riveting these stays there will be eighty-eight rivets to drive at about four minutes each, taking about six hours; cost $2.94. Cutting the threads on the two lower through stays one hour at 18 cents equals $0.18. Making the eyes in the other end of these stays will take about two hours, and welding them to the stays will take two hours; total four hours; cost $1.92.

The tubes must now be inserted. It will take all of twenty minutes per tube to insert, expand and bead them, or twenty-four and one-half hours; cost: one handy man at 18 cents equals $4.41. Placing the brackets and nozzles gives about seventy rivets to be driven with the air hammer. At four minutes per rivet this takes about four and one-half hours, and costs $2.20.

The boiler is now finished with the exception of calking the heads and the plate under the nozzles, testing, painting and loading. Calking the heads, etc., would take about three hours; cost at 20 cents equals $0.60. Painting will take two hours at 22 cents, equals $0.44, and 5 pounds of paint at 25 cents equals $1.25; total $1.69. Testing and loading can safely be estimated at $10.00. Summing up our total cost we have

Laying out shell plates and butt straps	$4.20
Shearing plates and butt straps	1.73
Planing plates and butt straps	2.35
Punching plates and butt straps	4.50
Rolling plates and butt straps	4.00
Riveting shell (bull machine)	5.40
Calking shell	1.20
Laying out heads	2.40
Flanging heads	9.30
Punching heads	1.50
Drilling centers, tube holes, $1.80; Cutting tube holes, $4.41	6.21
Making, shrinking and finishing manhole ring	3.40
Riveting heads to shell bull machine, $0.68; Riveting heads to shell air hammer, $2.94	$3.62
Making crowfeet, $17.76; Forging and welding stays, $21.12	38.88
Riveting stays	2.94
Through stays	2.10
Inserting tubes	4.41
Riveting brackets and nozzles	2.20
Calking heads and nozzles	0.60
Painting	1.69
Testing and loading	10.00
Total labor	$112.63

For our material we have:

Shell plates, 6,492 pounds, at 2 cents	$129.84
Butt straps, 552 pounds, at 2 cents	11.04
Heads, 1,471 pounds, at 2.1 cents	30.89
172 feet, 1⅛-inch stay iron = 585 pounds, at 2 cents	11.70
20 feet, 1½-inch stay iron = 120 pounds, at 2 cents	2.40
37 feet, 2½-inch by ¾-inch iron (crowfeet) = 231 pounds, at 2 cents	4.62
5 feet, 4-inch by 4-inch by ½-inch angles = 64 pounds, at 2¼ cents	1.44
1,332 feet, 4-inch tubes, at 18 cents per foot	239.76
Rivets (4 percent plate) = 340 pounds, at 3 cents per pound	10.20
Cast iron, 250 pounds, at 2½ cents	6.25
Total cost material	$448.14
Total cost of boiler	560.77

THE SELLING PRICE.

To get the ultimate selling price to give to the inquirer we have two more additions to make to the cost price. One is what is called "fixed charges," and is added to cover the non-productive expenses, such as foreman's salary, depreciation of plant, interest on investment, taxes, office expenses, etc. This will vary in almost every plant, and in this case is figured as 30 percent of the cost of manufacturing. Then 30 percent of $560.77 equals $168.23, making the total when added $729.00. The other addition is the profit, and in this case it is taken as 10 percent of the total cost of the boiler, or 10 percent of $729.00, which equals $72.90. Adding this we get $801.90 as the price sent to inquirer. Now, as round figures are generally used the price sent would probably be $805.00.

In closing, the writer would suggest to anyone who intends to do estimating along similar lines, that he keep tab on the different jobs as they go through the shop, putting down in a notebook, in tabulated form, the time taken for each part of the work and the cost of same as shown by the factory cost cards (if such are kept). On comparing these with his first approximation he will be able to see just where he has over or under estimated, as the case may be, and will be able to average very closely the right charge or cost for future reference.

The preceding method of estimating the cost of boiler work is very similar to that used on all descriptions of tank work, and the estimator would find it very convenient to have tank, boiler, stack and similar work divided into different classes under such heads as the following:

Heavy straight forward work (return tube boilers, etc.).
Heavy difficult work (marine boilers, flumes, kettles, etc.).
Light work (tanks, 3/16-inch plate and under, etc.).
Stack work, etc.

Having tables of work like this ready at hand, with the cost computed at so much per pound of material (averages being struck from various jobs), the estimator will be able to quote prices very closely by just figuring the weight of the proposed work. It is interesting to note how comparatively small is the variation of the ratios of cost of labor to cost of material under the different headings as just outlined.

A Single-Tube Boiler.

In discussing the steam plant of the White motor car before the American Society of Mechanical Engineers, Prof. R. C. Carpenter applied the term "single tube or continuous flow" to the type of boiler used on this motor car, whereas the boiler was popularly known as a flash boiler. He says: "In the flash boiler, as I understand the term, water is suddenly converted into steam by coming in contact with a very hot metallic surface, and in the operation of such a boiler the metal with which the steam is brought in contact is maintained at a much higher temperature than that of the steam. The White boiler contains a considerable amount of water, which is forced downward and over the heating surface at a rate proportionate to the demand for steam, and under its normal mode of operation it is doubtful if the metallic surfaces have much or any higher temperature than that of the steam which they contain. The name 'continuous flow or single-tube boiler' would, it seems to me, better describe the class to which the White boiler belongs than the term flash."

The White boiler is designed to generate on a small scale steam of very high pressure with a high degree of superheat. The outcome of this design is a boiler remarkable in many respects, especially for the means provided for automatic control of the quantity, temperature and pressure of the steam produced.

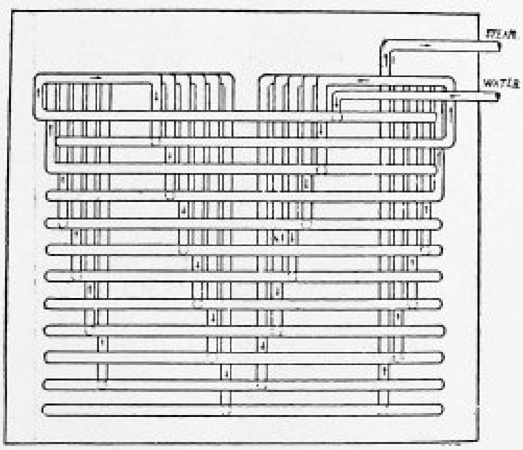


FIG. 1.—ARRANGEMENT OF COILS.

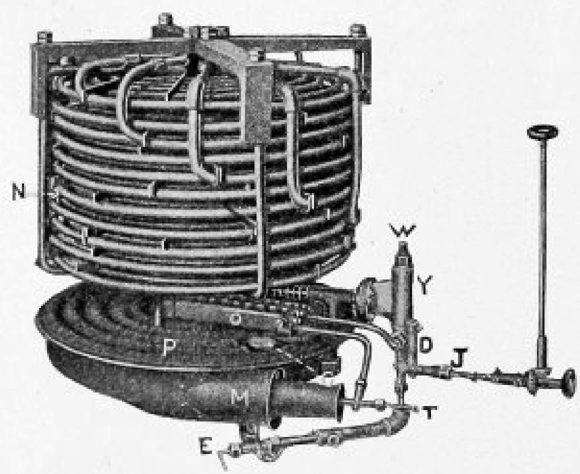


FIG. 2.—BOILER, BURNER AND CONTROLLING APPARATUS.

The steam generator or boiler consists of a series of horizontal coils connected so as to form a continuous tube through which all the water fed to the boiler and all the steam discharged from the boiler must pass. It is not provided with any reservoir either for water or steam. A perspective view of the boiler as used in the 1906 car is shown in Fig. 2, with the external casing removed. Its essential feature distinctive from every other boiler is due to the fact that the water is kept at the top and the steam at the bottom; it differs from all types of stationary boilers by the absence of a reservoir for steam. The construction of the boiler for the 18-brake horsepower engine which was used in the 1906 cars is essentially as follows, and is typical of all sizes; eleven helical coils of drawn steel tubing are joined in series and connected, as shown in the diagram, Fig. 1, so as to produce a system of circulation of such a character that the water or steam, in order to pass from one coil to that next below, must rise to a level above the top coil before it can pass down again. Fig. 2 shows the external view of the connections referred to, which pass from the external circumference of the coil upward to a point above the level of the top coil, and thence downward in the central space, where it joins the coil of a lower level. Tubing having a nominal internal diameter of 3/8 inch was used in the boilers of 1904, 1905 and 1906, and 1/2 inch in the new boiler recently built for the 1907 car. The joints connecting the various coils are, it is noted, located in an accessible position. This construction makes it possible to maintain water in the upper portion of the boiler and steam in the lower. It prevents the water from descending by gravity and renders the circulation through the generator dependent upon the action of the pumps which supply the boiler with water. The general direction of circulation of the water and steam is the reverse of that of the products of combustion.

The construction of the boiler has been shown and described, from which it is seen that the diameter of each pressure element is small, and consequently of great strength and not likely to be strained to any high percentage of its ultimate strength by any pressure which could be produced under ordinary conditions. The strength of the fittings at the point of leakage for the tubing was found to vary from 7,000 to 18,000 pounds per square inch.

The high working pressure gives great power to the engine, and explains the great success of the car in climbing high hills and in passing over unusually bad roads. A safety valve, not shown in the drawing, is attached, which may be set at any desired pressure but is usually set to blow off at from 1,000 to 1,200 pounds per square inch. Because of the small quantity of water and steam present in the boiler no serious damage is probable to person or property, even should the boiler tube be accidentally split or ruptured, as the effect would be simply that of allowing the steam to gradually escape without producing any disastrous results, and even this accident has been extremely rare. Considering the fact that thousands of these steam generators are in use, in the charge of men who have had practically no experience in the operation of steam plants, the results as to freedom from accident are remarkable, and indicate that the apparatus is, from the standpoint of safety, not open to criticism.

An attempt has been made to get data respecting the amount of deposit of scale in the tube of the White boiler, due to its continued use, but without any very great degree of success. Investigation indicates that there has been very little practical difficulty due to this deposit, and the makers report only a few instances which have come to their knowledge of any trouble due to this cause. The velocity of discharge of steam through the single tube of the boiler is great, and it is believed has been sufficient to remove the deposits in nearly every case. As much as 488 pounds of steam have been produced per hour by the ½-inch tube. Without taking into account the extra volume produced by superheat, the calculated velocity approximates 400 feet per second through the tube. Because of increased volume, due to the high degree of superheat, the actual velocity approximates one-third more.

For the actual operation of the White boiler on the motor car, water is taken from a reservoir which is supplied in great part with water condensed in an air surface condenser. The condenser is located at the front of the car and receives the exhaust from the engine which contains an appreciable amount of cylinder oil. A large proportion of this oil remains in the water tank and is discharged when convenient, but at times quite a considerable amount is forced through the boiler. So far as the makers have been able to ascertain, no injurious effects have been caused by this practice, and as a consequence they have made no attempts to introduce a separator for removing this oil.

The furnace or burner which is employed with the steam generator for use on the motor car is shown at *P*, Fig. 2, located beneath the boiler and adapted for the burning of gasoline vapor. The figure also shows the various means of automatic control of fuel and water which are employed with the generator. While burners of other types adapted for other fuels than gasoline can and doubtless will be used when conditions demand it, the gasoline burner employed has proved very efficient. In the burning of gasoline a vapor must first be produced by heat or other means which must be mixed with air previous to the combustion in order to give perfect results and high efficiency; for this reason all gasoline burners are provided with means for vaporizing the gasoline before it is fed to the furnace, which usually consists of means for heating termed a *vaporizer*, as is shown at *O*, Fig. 2. The burner consists of a cast-iron grate with slotted openings, shown at *P*, with a sheet metal chamber underneath, closed except where pipes enter for admission of air, as shown at *M*. In the 1905 car, the air pipes were directed radially into the chamber below the burner. In the 1906 car the air pipes direct the entering air tangentially, as shown in Fig. 2. The change in the direction of the air pipes has resulted in a decided reduction of noise and an increase of capacity and efficiency of the burner. For the 1907 car the air pipe is supplied with a regulating valve. The gasoline is supplied through a pipe and flows past a valve *D*, which is operated by a thermostat; it then flows into the vaporizer *O*, where it is heated; thence it flows to the center of the air pipe *M*.

The thermostat shown at *Y* in Fig. 2 consists of a rod inserted into the steam pipe so as to be in contact with the steam on its passage from the boiler to the engine. The expansion of this rod controls the gasoline valve at *D*, Fig. 2. The thermostat is ordinarily adjusted so that the oil supply valve will remain open until the temperature of the steam rises to about 800 degrees F. In order to light and relight the main burner, when necessary, a small gasoline flame called a pilot flame, shown at *C*, Fig. 2, is kept burning constantly during the time the vehicle is in use. The valves for the hand control of the gasoline supply are shown at *L*, Fig. 2. In the operation of the burner the gasoline is discharged with considerable velocity, and while in a vaporized condition into the air pipe *M*, Fig. 2, and by this operation draws in a sufficient amount of air for supporting combustion, which is mixed with the gasoline vapor and burns with a hot flame on top of the cast-iron grating.

For the purposes of use on the motor car it is also desirable to have an automatic control of the supply of water; this is obtained in the White motor car by means of a pump which is directly connected to the engine and which may deliver either directly into the boiler or into the source of supply, depending upon the opening of a valve controlled by the steam pressure acting against a spring. If the pressure rises above 400 pounds, or to any desired amount, a valve is opened so as to return the water through an opening to the

INTERIOR VIEW OF BOILER SHOP OF WM. DOXFORD & SONS, LTD.

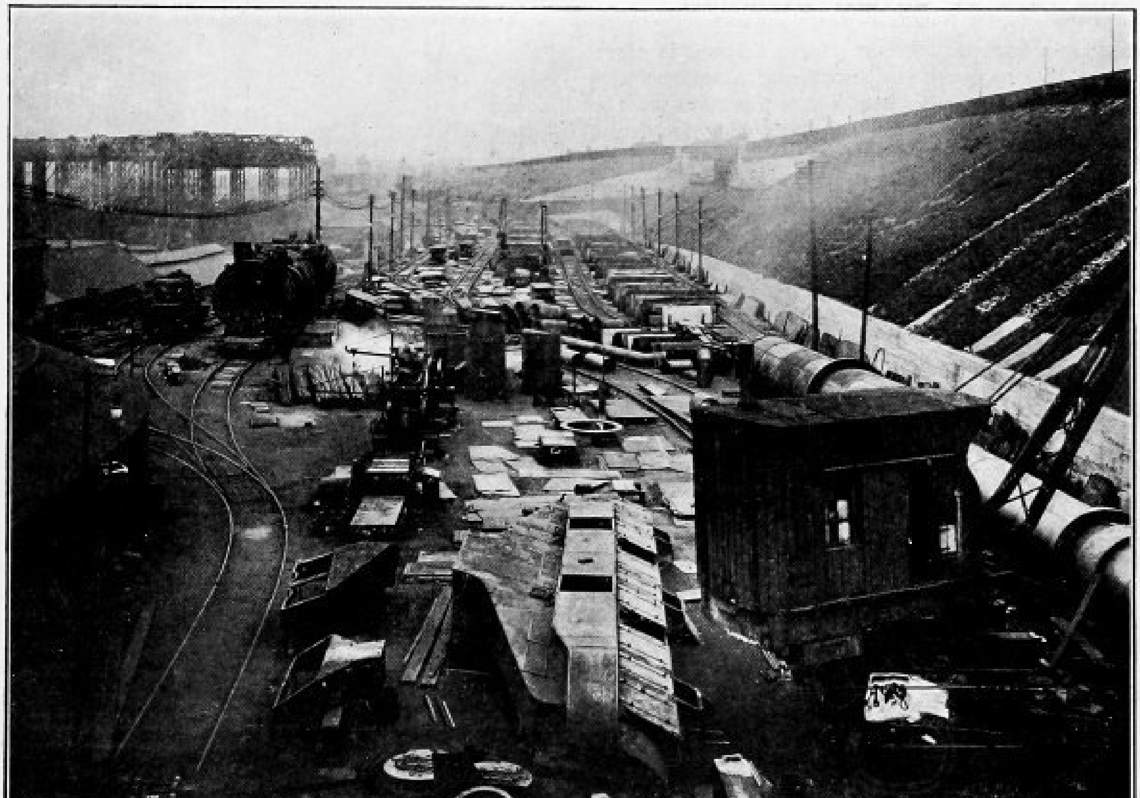
source of supply. If, on the other hand, the pressure is below the required amount, the valve is closed by the tension of the spring and is forced by the pump into the boiler.

It is noted by the illustration, Fig. 2, that no water gage is supplied to the boiler, and from the description of its operation it is seen that none is necessary.

In the operation of the plant, as applied to a steam car and provided with the automatic devices as described, the fuel and water are supplied as the demand for steam requires, with scarcely any attention on the part of the operator. Thus, for instance, if the steam pressure becomes excessive, the water supply is closed off by the water regulator, which immediately causes the pressure to drop. If the temperature of the steam becomes excessive, which would soon be the case if the water supply were turned off, the fuel supply is cut off by the thermostat, which soon reduces the temperature to the normal amount. On the other hand, if there is an excessive amount of steam drawn off, the pressure and temperature drop, and both the water and fuel supply is increased.

The Boiler Shop at the Shipyard of William Doxford & Sons, Ltd.

A large and well equipped boiler shop is located at the shipyard of William Doxford & Sons, Ltd., Sunderland, on the northeast coast of England. The present equipment of the plant was installed about 1880, although the yard was started at Pallion in 1857, and the present site was cleared in 1869. The work carried on in this shop is principally the construction of Scotch marine boilers for installation in the peculiar type of ship built at this yard. These ships are nearly all of the turret type of cargo steamers. The advantage of this type of ship lies in its seaworthiness, on account of which it can make quicker passages in rough weather than the ordinary type of cargo steamer. The peculiar shape of this type of ship makes it particularly adapted for carrying cargo, as it can be constructed with large holds unobstructed by beams or stanchions. Since 1900, when the tonnage turned out by this yard was 34,829, the output has been increased steadily until in 1906 it amounted to 106,158 tons, comprising a total of twenty-five ships.



BOILER PLATE AND STOCK YARD AT THE SHIPYARD OF WM. DOXFORD & SONS, LTD.

In 1901 the engine and boiler shops were destroyed by fire, and advantage was taken of the necessity of putting in new works to bring them thoroughly up to date. In 1906 the entire plant was equipped with electric drive throughout. This method of generating and transmitting power has been carried to such an extent that at the present time even the power for hydraulic and pneumatic pressure is secured by means of electric motors. The power for one section of the yard is generated by four units, each of 250 H. P., driven by a triple-expansion, surface condensing, vertical engine, operating at 160 pounds pressure per square inch. Current for the remainder of the yard is taken from private companies.

The boiler shop is 350 feet long and is divided into four

Cost of Riveting

The following comparison of the cost of machine and pneumatic riveting is given on the authority of the Chester B. Albree Iron Works Company, Allegheny, Pa. Since a machine will drive rivets as fast as they are fed to it, the chief cost is that of handling the work. This varies with the class of work, heavy and bulky work being, of course, harder to handle. Assuming $4.50 a day for the labor, exclusive of the heater, if a machine drives some 700 or 800 rivets a day the cost for labor, power and general charges will be from 5/8 to 3/4 cent per rivet. Pneumatic hammer rivets in ordinary shop work will cost hardly less than 1 1/2 cents per rivet for similar charges. Assuming only 1/2 cent saved per rivet, there is $1,000 or $1,200 saved per year. A much greater saving will generally result, for if double the machine rivets are driven per day the cost per rivet is practically cut in half.

bays, two of which are 49 feet wide and two 32 feet wide. Each bay has four overhead traveling cranes. The cranes in the wider, or 49-foot bays, have a capacity of 80 tons each. In addition to the overhead traveling cranes individual machine tools are served by light jib cranes. The use of electric motors on individual machines has done away with the use of line shafting except in cases where two or three single machines are operated continuously, in which case one motor serves to drive a short section of light shafting.

The shop is well built and conveniently arranged. It is lighted by means of skylights in the roof, and in addition electric arc lamps are provided for dull weather and night work. As can be seen from the illustration, showing the boiler and plate stockyard, some of the lighter sheet metal work is assembled and riveted up in the yard. Small locomotive cranes, one of which can be seen in the photograph, serve to handle the material outside the shop.

The Area of Circular Segments.

In laying out a horizontal return tubular boiler it is necessary to know how to figure out the area of a segment of a circle. That part of the boiler head above the tubes must be braced either by through or diagonal stays, and in order to determine the size and pitch of these stays the area of this portion of the head must be determined.

It may be safely assumed that the upper row of tubes in the boiler will act as stays for a portion of the lower part of the

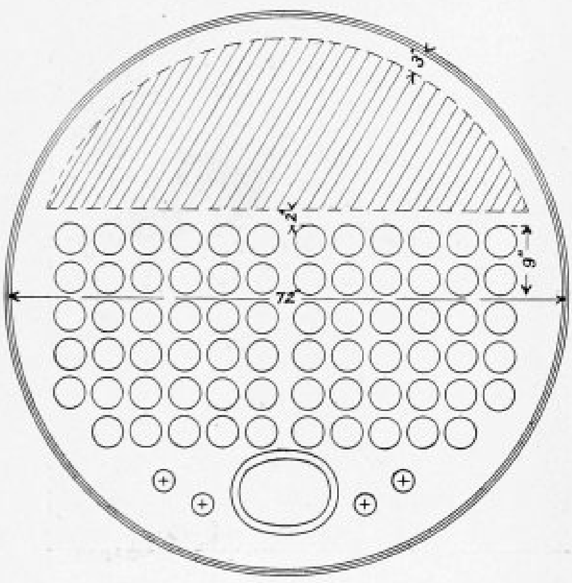


FIG. 1.

segment, and also that the flange of the head will serve to stay the edge of the plate. There is no definite way of determining just how much of the head is securely braced in this way, but practice has shown that if 2 inches are allowed above the top row of tubes and 3 inches from the edge of the flange, the results will be well within the margin of safety. There is left, then, as the area to be braced, the segment shown shaded in Fig. 1; the diameter, length of chord and height of which can be easily found. Since a strip 3 inches wide is considered to be braced by the flange of the head, the diameter of the circle of which the shaded part is a segment, according to the dimensions shown in Fig. 1, is 72 — 6, or 66 inches. The height is 33 — (2 + 7), or 24 inches. One-half the length of the chord is a mean proportional between the two parts of the diameter, which it intersects at right angles, or

$$\left(\frac{\text{chord}}{2}\right)^2 = \text{height} \times (\text{diameter} - \text{height}).$$

The most direct way of finding the area of this segment is to first obtain the area of the corresponding sector and

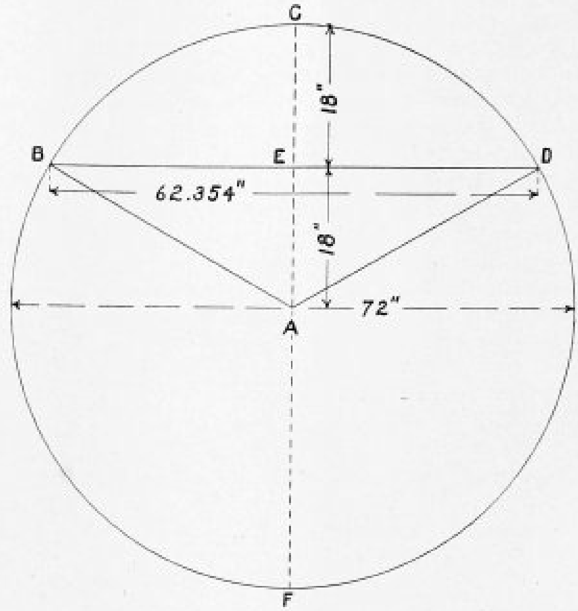


FIG. 2.

subtract from this the area of the triangle formed by the chord of the sector and the radii to its extremities; for instance, in Fig. 2 the segment *BCDE*, which has a height of 18 inches, is equal to the area of the sector *ABCD*, minus the area of the triangle *ABED*. It will first be necessary to find the length of the chord *BED*.

Since *BE* is a mean proportional between *CE* and *EF*, $(BE)^2 = CE \times EF$; $(BE)^2 = 18 \times 54 = 972$; $BE = 31.177$, therefore, the length of the chord is 62.354 inches.

The area of a sector is equal to the length of the arc times one-half the radius. If it were possible to measure directly the length of the arc *BCD* this would be a simple calculation. This, however, can seldom be done with any accuracy, and therefore it is necessary to make use of trigonometry in order to get the length of the arc. The length of the arc equals the length of the circumference of the entire circle times the number of degrees in the arc *BCD* (or in the angle *BAD*) divided by 360.

Therefore,

$$\text{area segment} = \frac{\text{circumference of circle} \times \text{degrees in arc} \times \text{radius}}{360 \times 2} - \frac{\text{chord} \times (\text{radius} - \text{height})}{2}$$

The number of degrees in the arc may be found by first finding the angle *BAC*. The sine of this angle equals

$$\frac{BE}{BA} = \frac{31.177}{36} = .866.$$

Looking up the angle corresponding to this sine in a table of natural sines and cosines, we find that the angle *BAC* is 60 degrees, and therefore the angle *BAD*, which is twice the angle *BAC*, is 120 degrees, or the arc *BCD* equals 120 degrees. Of course, in this particular case it will be seen at once that the angle *BAC* is an angle of 60 degrees, since the side *AB* of the triangle *ABE* is twice the length of the side *AE*. In nearly every case, however, it will be necessary to make use of a table of natural sines or natural tangents in order to determine the number of degrees in this angle.

Having found these values, substitute them in the formula for finding the area of a segment as follows:

$$\text{Area} = \frac{3.1416 \times 72 \times 120 \times 36}{360 \times 2} - \frac{62.354 \times 18}{2}$$

$$\text{Area} = 1{,}357.171 - 561.186.$$

$$\text{Area} = 795.985 \text{ square inches.}$$

While the above method is the exact method for finding the area of a segment of a circle, it is by no means a simple and convenient computation to make in practice, and it is practically useless unless a table of natural functions of an angle is at hand. Therefore, it is necessary to use some more convenient, even if less accurate, method for finding this area.

Perhaps the simplest and most convenient method is to make use of a table in which the area of the segment has been computed for different ratios of height to diameter for a circle one unit in diameter. Then multiplying this area by the square of the diameter gives at once the required area of the segment. The accuracy of this method depends upon the number of decimal places to which the table is worked out. Such a table is given below, and using the segment which is figured out from Fig. 2, as an example, we find that the height of the segment divided by diameter of circle = .25. Looking up .25 in the column of height divided by diameter, we find the corresponding area for a circle one unit in diameter = .153546; $.153546 \times (72)^2 = 795.983$ square inches.

Height ÷ Diameter.	Area.	Height ÷ Diameter.	Area.
.01	.001329	.26	.162263
.02	.003749	.27	.171090
.03	.006866	.28	.180020
.04	.010538	.29	.189048
.05	.014681	.30	.198168
.06	.019239	.31	.207376
.07	.024168	.32	.216666
.08	.029435	.33	.226034
.09	.035012	.34	.235473
.10	.040875	.35	.244980
.11	.047006	.36	.254551
.12	.053385	.37	.264179
.13	.059999	.38	.273861
.14	.066833	.39	.283593
.15	.073875	.40	.293370
.16	.081112	.41	.303187
.17	.088536	.42	.313042
.18	.096135	.43	.322928
.19	.103900	.44	.332843
.20	.111824	.45	.342783
.21	.119898	.46	.352742
.22	.128114	.47	.362717
.23	.136465	.48	.372704
.24	.144945	.49	.382700
.25	.153546	.50	.392699

There are a number of approximate rules for finding the area of a segment which give results varying by only a few percent. In the first place, the area of a segment may be computed by Simpson's rule for finding the area of any irregular figure bounded by curved lines. This rule is as follows: Given the segment shown shaded in Fig. 3, first measure the length of chord, 68 inches; divide this chord into eight equal parts and draw the vertical lines shown dotted at these points. Only four of these lines are shown in the figure, as those on the other side of the center line will have corresponding lengths. Measure the length of each of these vertical lines and then multiply the length of the center line (25⅝ inches) by 1; the next one (24 inches) by 4; the next one (20¾ inches) by 2, and the last one (14¼ inches) by 4. Add all of these products together, multiply the sum by the base of the segment (68 inches) and divide the result by 12. This rule could be depended upon for very good accuracy if the measurements could be accurately made, but due to the difficulty of making accurate measurements the rule is somewhat clumsy to use.

A modified form of the foregoing rule may be used, which will give results with an accuracy of 4 or 5 percent as against an accuracy of approximately 1 or 2 percent in the first case. In this rule it is necessary to measure only the following distances:

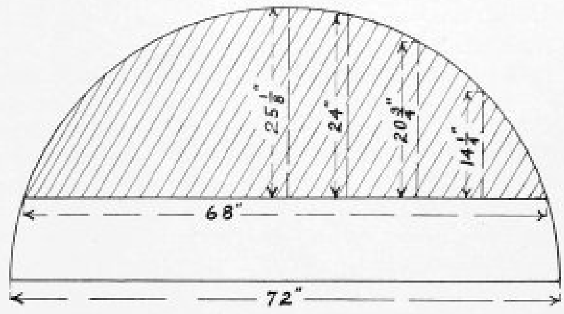


FIG. 3.

The chord (68 inches), the height (25⅝ inches), and the vertical line which divides the chord into quarters (20¾ inches). Add the length (25⅝ inches) to 4 × 20¾. Multiply the sum by the base (68) and divide by 6.

A somewhat rougher approximation for the area of a segment may be obtained, as shown in Figs. 4, 5 and 6, where the area of the entire semi-circle is first obtained, and then an area equivalent to the difference between the entire semi-circle and the segment is subtracted from this. The area of the entire semi-circle is $\frac{1}{2} \times 3.1416 \times R^2$. The area to be subtracted from this can be approximated in either of the following three ways: In Fig. 4 this area is considered as a rectangle whose base is equal to the diameter of the circle, and whose height is equal to the difference between the radius of the circle and the height of the segment. This area is evidently too large, and therefore the area of the segment will be too

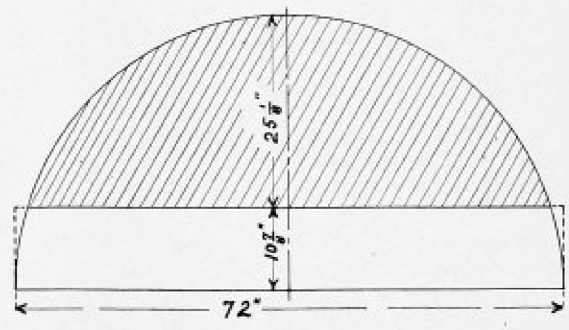


FIG. 4.

small. In Fig. 5 the equivalent area is taken as a rectangle whose base is equal to the length of the chord and whose height is equal to the difference between the radius of the circle and the height of the segment. This area is evidently too small, and therefore the resulting area of the segment will be too large. A closer approximation is shown in Fig. 6, where the equivalent area to be subtracted from the semi-circle is taken as a rectangle whose length is a mean between the diameter of the circle and the length of the chord, the height being the same as in the previous cases. The error due to using either of the last three rules is likely to run up to 5 percent or over, and therefore they should be used only when an aproximate value is desired.

The following rule has been devised by the editor which can be used with ease and accuracy whenever the height of the segment is greater than one-half the radius of the circle. As in the foregoing rule, first find the area of the semi-circle and from this subtract the area of the rectangle, shown dotted in Fig. 7. The width of this rectangle is equal to the difference between the radius of the circle and the height of the segment. Its length is equal to the length of the base or chord of the segment plus .676 times the difference between the diameter of the circle and the length of the chord. For the dimensions

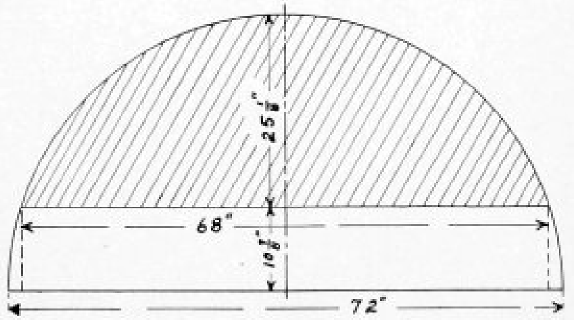


FIG. 5.

shown in Fig. 7, the exact area of the segment, as given by the table, is as follows:

$$\frac{\text{height}}{\text{diameter}} = .3.$$ Area of a segment of this ratio of height to diameter in a circle one unit in diameter is given as .198168. Multiplying this by the diameter squared $.198168 \times 60^2 = 713.4048$ square inches.

The area of a segment, according to the rule just given, is as follows: The area of the semi-circle equals $3.1416 \times 30^2 =$

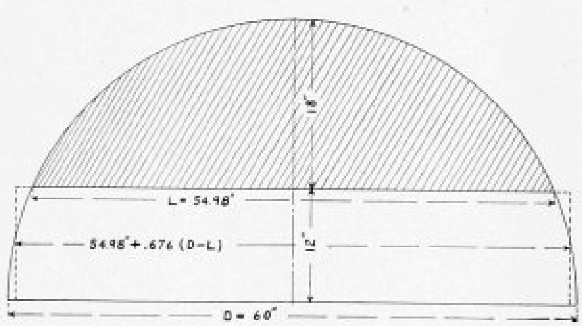


FIG. 7.

1,413.72 square inches. One-half the length L is a mean proportional between the height of the segment and the diameter minus this height. Therefore, $\left(\frac{L}{2}\right)^2 = 18 \times 42$, or $\frac{L}{2} = 27.49$ and $L = 54.98$ inches. Therefore the length of the equivalent rectangle is $54.98 + .676 \times (60 - 54.98) = 58.3735$ inches. This length times the width of rectangle (12) equals 700.4822 square inches, the area of the rectangle. The area of the semi-circle, which was found to be 1413.72, minus the area of the rectangle, equals 713.2378 square inches. Comparing this value with the exact area we find the error to be only .023 percent. Calculating the area of the segment accurately by means of a table and then by the method just given for segments 6, 12, 18 and 24 inches in height for a circle 60 inches in diameter, shows that where the height of the segment is greater than one-half the radius, in this case greater than 15 inches, the percentage error from using this rule is very small indeed, being only a few hundredths percent. For the smaller segments the percentage rapidly increases, so that for the segment only 6 inches high the percentage error is nearly 9. These results, tabulated in the following table, have been

AREA OF SEGMENTS IN 60-INCH CIRCLE.

Height of Segment.	Area Figured from Table.	Area Figured by Short Rule.	Percentage Error of Short Rule.
6".....	147.15	160.344	8.96
12".....	402.5664	403.704	.282
18".....	713.4048	713.2378	.026
24".....	1056.132	1056.0917	.0026

plotted in Fig. 9 on the bases of the corresponding segments and a smooth curve drawn through the points. This curve

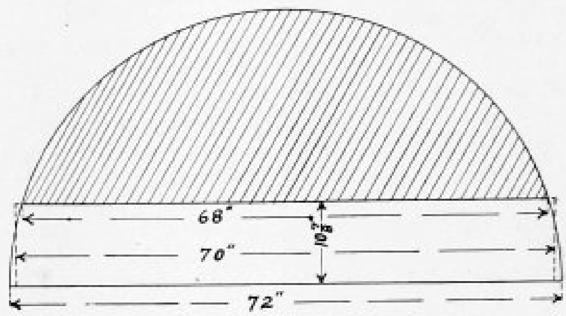


FIG. 6.

shows then in a rough way the percentage of error which might be expected from using this rule. The accuracy of the rule where the height of a segment is greater than one-half the radius is very apparent. Furthermore, the rule is very easy to use, as it is simply necessary to remember or have noted down in a convenient place the constant .676 used in finding the length of the equivalent rectangle.

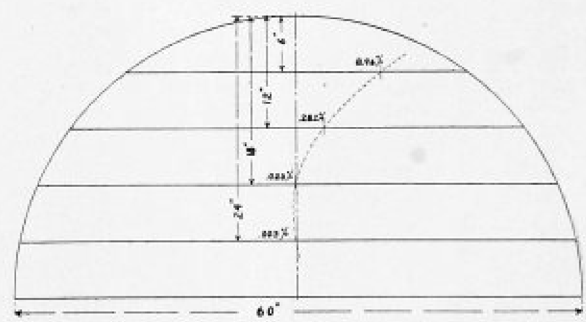


FIG. 8.

Two good rules for finding the area of a segment which are not generally known were given in a recent issue of *The Locomotive*. The first of these was devised by Mr. C. E. Platt, inspector of the Southeastern Department of the Hartford Steam Boiler Inspection & Insurance Company, and gives a sufficient degree of approximation for most practical purposes, and furthermore is easy to use. It is as follows: "Subtract the height of the given segment from the radius of the circle and multiply the result by the diameter of the circle, diminished by 1 inch. Subtract the product so found from the area of the semi-circle of which the segment forms a part, and the result is the approximate area of the segment. All measurements are to be made in inches." It will be seen that this rule is similar to the one last mentioned except that, instead of taking the area of a rectangle whose length varies according to the difference between the diameter of the circle and the base of the segment, the length of the rectangle is in every case taken 1 inch less than the diameter of the circle.

The other rule was devised by the editor of *The Locomotive*, and although somewhat complicated, gives very accurate results and can be solved by simple arithmetic. Quoting the explanation of this rule as given by the author.

"The measurements that must be known in order to apply this more accurate approximate formula are shown in Fig. 9. The shaded area A here represents the segment whose area is to be determined, and CD is a diameter of the circle to which the segment belongs, CD being parallel to the base of the segment EF. The lengths denoted by the various letters in the diagram will be apparent without explanation, with the possible exception of M, which is the distance, measured in a *straight line,* from F, the extremity of the base of the segment, to D, the corresponding extremity of the diameter CD. The lines R, H, L and M can all be directly measured if desired, but it is not necessary to measure more than two of them, since when two are known, the others can be calculated. For example, if

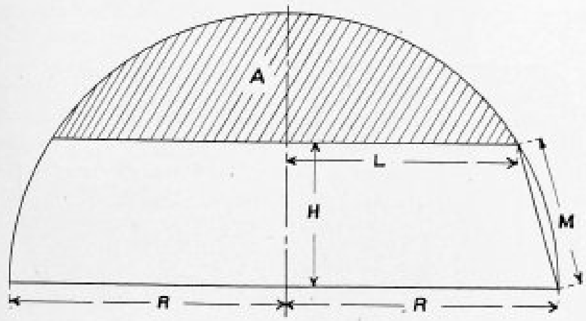


FIG. 9.

we measure R, the radius of the circle, and H, the perpendicular distance from the center of the circle to the base of the segment, then we may calculate L and M as follows: For finding L we have the relation $L^2 = (R + H)\ (R - H)$; and when L has been obtained in this manner, we may find M from the relation $M^2 = 2R\ (R - L)$.

When we know R, H, L and M, either by direct measurement or otherwise, we may obtain a very accurate value of the area A (except when the height of the segment is very small) by means of the formula:

$$A = 1.5707963\ R^2 - H\left(L - \frac{R}{3}\right) - \frac{4RM}{3}$$

The first term to the right of the sign of equality represents the area of the semi-circle, the number 1.5707963 being one-half of the familiar decimal number 3.1415926, by which the square of the radius must be multiplied, in order to obtain the area of the whole circle.

The area of a segment 18 inches high, in a circle 72 inches in diameter, is found, by this formula, to be 796.09 square inches, whereas, the true area of such a segment was found to be 795.98 square inches. In this case, therefore, the approximate formula last given is in error by only about 0.11 square inches, or by about one-eightieth part of 1 percent. The formula gives results that are still more accurate, when the segment is more nearly equal to a semi-circle.

There are at present fifty mallet-articulated compound locomotives in service in the United States, distributed over four roads. The Great Northern Railway has twenty-five in road service, the rest being in pushing service as follows: Northern Pacific Railway, 16; Great Northern Railway, 5; Baltimore & Ohio Railroad, 1, and Erie, 1.

The temperature produced in the oxyacetylene blow-pipe is said to be as high as 6,300 degrees F. Welding by this method is replacing the process of riveting in many instances.

Packing Flanged Joints.

BY C. R. MC GAHEY.

A new high-speed automatic engine had to be connected to an old pipe line that was not put up straight, so that when the flange next to the throttle was put on it was open on one side about one-eighth of an inch more than on the other, as shown in Fig. 1. I separated the flanges as much as possible and put in two sheets of sheet-packing one-sixteenth of an inch in thickness on the thin side and three sheets on the open side. Then I came down on my bolts good and hard and turned on a little steam. This softened up the packing, and, contrary to all engineering tenets, I continued to screw up the bolts with the steam on, and they came all right. Soon the packing began to force out around the flange, and I put on the full pressure, 115 pounds, and continued taking up on the bolts until the joint was vulcanized. It had been there three years when I left the section, and never leaked a drop.

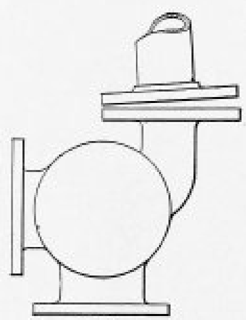


FIG. 1

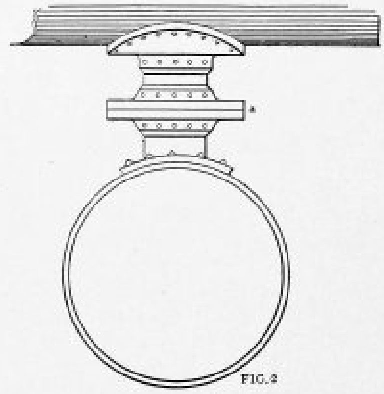


FIG. 2

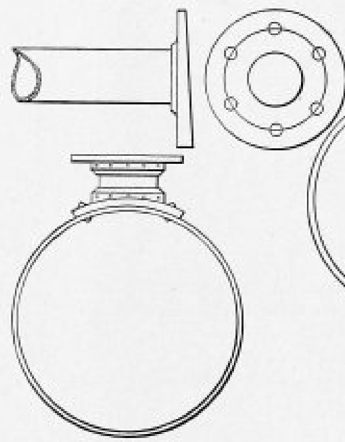


FIG. 3

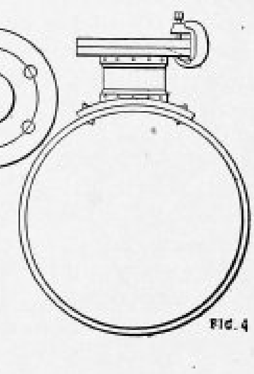


FIG. 4

Another bad job was packing the flange between a mud-drum and the boiler, shown in Fig. 2. They were wrought-steel flanges, not faced and hard to keep tight. We got around it by using two corrugated copper gaskets, filling in the indentations with good stiff red lead. It had to stand a pressure of 180 pounds and upward, and it did it.

In making a joint of this kind it is well to mix raw cotton in the lead. This acts as a binder and makes a good filling for a place like this.

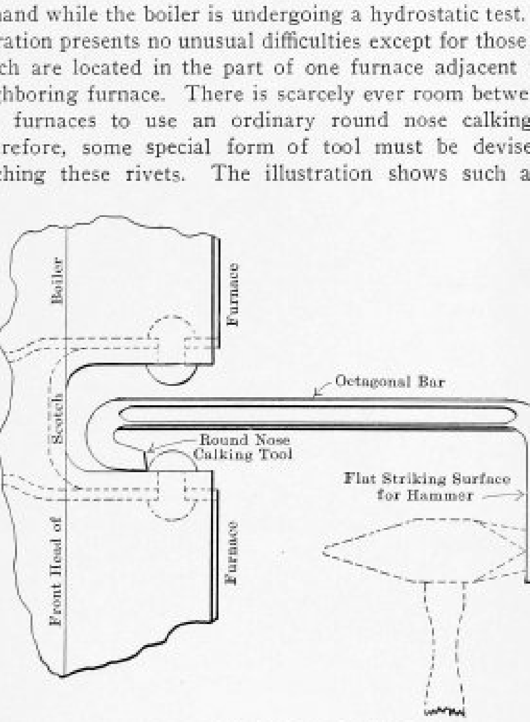
A wrought-iron flange was bent in unloading as shown by the dotted lines at D in Fig. 3. We got a heavy flange and some clamps that would span them as shown. When we had our rigging ready we built a charcoal fire under the bent flange, and as soon as we got it hot enough we put the heavy flange over it and drew it up so that no one could have told that it had been bent.

At another time we had some boilers, the steam nozzles of which were put on crooked as in Fig. 4. There was a 122-foot line of 6-inch pipe leading off from these nozzles, and we had to get it straight, so we had some flanges made as shown at *M*, Fig. 4. Having a stop valve and a chance to get in two such flanges, we got the needed corrections made close to the boiler and it did not look unsightly.

If you want to open a flange joint soon, rub a little chalk over the face of the packing. This will cause the packing to leave the flange clean and save the packing. In making joints where a considerable thickness of packing is required, I have found it advisable to use two thin sheets of rubber placed one on top of the other and breaking joints. This answers well for a long, narrow joint, and will hold under severe conditions. An uneven joint is bad, because when the flange is down hard in some places it does not bind the packing in others, and just where the packing is held the least tightly it presents the greatest thickness for the steam pressure to work upon to force it out. The thinner the packing that can be used, the better. I have used tin foil, but this must be on a smooth joint. For water, I prefer the cloth insertion rubber. It costs less and answers every purpose.—*Power.*

A Convenient Tool for Calking Rivets.

It frequently happens that in driving up the rivets in the furnace ends of Scotch marine boilers the rivets cannot be made perfectly tight with a portable hydraulic or pneumatic riveter. In such cases it becomes necessary to calk these rivets by hand while the boiler is undergoing a hydrostatic test. This operation presents no unusual difficulties except for those rivets which are located in the part of one furnace adjacent to the neighboring furnace. There is scarcely ever room between the two furnaces to use an ordinary round nose calking tool. Therefore, some special form of tool must be devised for reaching these rivets. The illustration shows such a tool,



METHOD OF USING SPECIAL CALKING TOOL.

which is used in one of the large marine boiler shops of the Middle West. A portion of the front head of a marine boiler where two of the furnaces are adjacent is shown, giving an idea of how inaccessible the edge of the rivet is for calking. The curved calking tool shown is made of any convenient sized bar ($\frac{7}{8}$ or 1 inch), octagonal throughout the straight portion in order that the workman may easily hold the tool without any possibility of its turning in his hand while being struck, with one end forged to a right angle and flattened on the inner side to form a striking surface for the hammer. The other end of the bar is welded to an ordinary round nose calking tool, which has been curved to the shape shown. An ordinary hand-chipping hammer is used with the tool.

Longitudinal and Girth Joints in Boilers.

All writers upon the subject of steam boiler design devote considerable space to the discussion of the longitudinal joints, but it has appeared to some of our readers that the girth joints have not received sufficient attention. For example, in boilers that are to withstand high pressure, the longitudinal joints are now usually made by abutting the plates, and securing one or two overlapping straps to the plates by means of two rows of double or triple riveting; while the girth joints on the same boiler are ordinary, single-riveted lap joints. It is the purpose

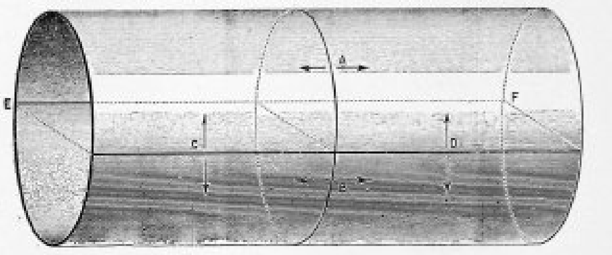


DIAGRAM SHOWING FORCES CAUSED BY STEAM PRESSURE.

of the present article to make it plain that this construction is correct, and that if the single-riveted girth joint is properly designed it is still considered stronger than the double-butt strap triple riveted longitudinal joint.

The cut represents a hollow cylinder of steel, an ideal boiler shell, without heads or joints. It is 66 inches in diameter and 14 feet long. The thickness of the metal is $\frac{3}{8}$ inch, and its tensile strength, let us say, is 55,000 pounds per square inch of section. If this shell is burst by steam or water pressure, the fracture can run longitudinally along the lines *E, F, D, C,* or around the boiler, along the line *BA*.

Let us first find the the bursting pressure, assuming that the fracture takes place longitudinally. At the moment of rupture the strain on the metal must be just equal to its tensile strength; that is, to 55,000 pounds per square inch. The area of plate to be broken, along the line *CD*, is $168 \times \frac{3}{8} = 63$ square inches, 168 being the length of the boiler in inches and $\frac{3}{8}$ being the thickness. The section along *EF* has the same area, so that the total area to be broken across is $2 \times 63 = 126$ square inches; and since the strain on each square inch is 55,000 pounds at the moment of rupture, the total strain on the section of rupture will be $126 \times 55{,}000 = 6{,}930{,}000$ pounds.

The total steam pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch multiplied by the area of the cross-section of the boiler, which area in this case is 168 (length of the boiler) $\times$ 66 (diameter of boiler) $= 11{,}088$ square inches. Those who are not familiar with this sort of calculation sometimes find it hard to understand why the surface of the shell is not used instead of the area of cross-section. The answer is that the pressure on the half *EAD*, for example, does not all act in the same direction, owing to the curvature of the shell. The pressure on parts that are close to the line *CD* acts almost horizontally, while on the parts lying along the top of the boiler it acts vertically. It would be easy to take these varying directions into account, but the same result can be reached without any figures, and in a very simple way. Suppose, for example, that the lower half of the boiler in the cut should be taken away, and that a flat plate should be bolted to the upper half in its place. If steam is now admitted, experience tells us that the boiler will not move either up or down; and it follows from this that the pressure against the curved half of the structure is precisely equivalent, so far as forcing the halves of the boiler apart is concerned, to that against the flat plate bolted to it. Hence, as was stated in the first part of this paragraph, the total pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch multiplied by the area of cross-section of the boiler (11,088 square inches).

The pressure that would burst a shell like that shown in the cut is of such a magnitude, therefore, that if it is multiplied by 11,088 square inches (the area on which it acts) the product will be 6,930,000 pounds. Hence the bursting pressure is $6,930,000 \div 11,088 = 625$ pounds per square inch. This is not the bursting pressure of a boiler of this size, but simply of a steel shell of the given dimensions; for we have not yet taken account of the joints that occur in boilers.

Let us now see what pressure would be required to force the boiler apart endwise, tearing it along the line *AB*. The only thing that can produce a strain acting lengthwise along the boiler, is the pressure on the head, which is equal to the steam pressure per square inch multiplied by the area of the head, the area of the head in the present case being $66 \times 66 \times .7854 = 3,421$ square inches.

To withstand the strain so produced we have a ring of metal at *AB*, which is 207.3 inches in circumference ($66 \times 3.1416 = 207.3$) and 3/8 inch thick. The area of this ring is $207.3 \times 3/8 = 77.74$ square inches; and when the shell is about to break the strain upon the section *AB* will be $55,000 \times 77.74 = 4,275,700$ pounds. When the boiler parts, therefore, the steam pressure must be such that, by acting on an area of 3,421 square inches, it produces a resulting strain of 4,275,700 pounds. Hence the bursting pressure per square inch is $4,275,700 \div 3,421 = 1,250$ pounds.

The results that we have thus far reached are, that it would take a steam pressure of 625 pounds per square inch to rupture a shell of the given dimensions longitudinally, and that it would take precisely twice this pressure, or 1,250 pounds per square inch, to rupture it circumferentially.

If the shell were made up of plates, riveted together, we should have to modify the foregoing calculation somewhat, so as to take account of the diminished strength due to the existence of the joints. Let us suppose there is a single-riveted girth joint whose dimensions are as follows: Diameter of rivets, 3/4 inch; diameter of rivet holes, 13/16 inch; pitch of rivets, 1 3/4 inches; tensile strength of plate, 55,000 pounds. It will be found that this joint has 53 percent of the strength of the solid plate; so that the pressure per square inch that would rupture such a shell circumferentially, so as to blow the two ends apart, would be 53 percent of 1,250 pounds; $1,250 \times .53 = 662.5$. It would therefore take a pressure of 662 1/2 pounds to the square inch to pull this girth joint apart. But from our previous calculation it appeared that a pressure of 625 pounds would tear the solid plate apart lengthwise; so that it appears that the solid plate would tear longitudinally before a properly proportioned single-riveted girth joint would fail. This is ample justification for the use of single-riveted girth joints, even when the longitudinal joints are butted and strapped and triple riveted.

Let us suppose that the boiler has triple-riveted butt-strap joints, the dimensions of the points being as follows: Strength of plate = 55,000 pounds per square inch; thickness of plate = 3/8 inch; diameter of rivet holes = 13/16 inch; pitch of inner rows of rivets = 3 1/4 inches; pitch of outer rows = 6 1/2 inches.

The efficiency of this joint can be shown to be 87.5 percent. The pressure that would rupture the solid shell longitudinally being 625 pounds, the pressure that would rupture a similar shell with a longitudinal joint proportioned as above, would be 87.5 percent of 625 pounds, which is 547 pounds; and the safe working pressure, allowing the usual factor of safety of 5, would be $547 \div 5 = 109$ pounds per square inch.

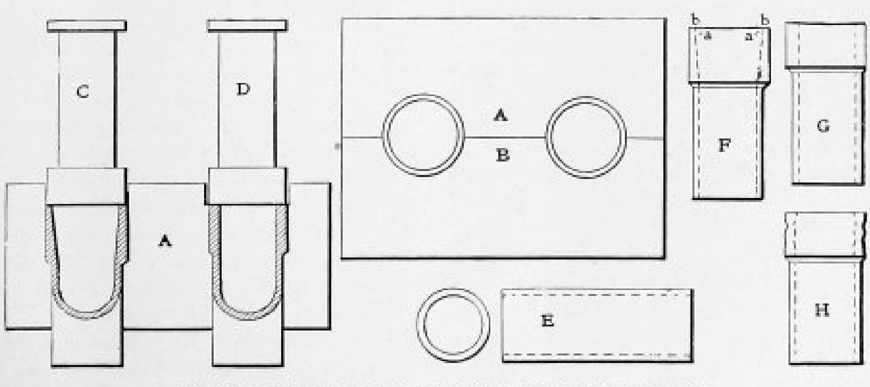
To illustrate the fact that a single-riveted girth joint is stronger than any form of longitudinal joint, we have taken a particular case and computed the strength in both directions. A general proof of the same fact might be given, applicable to all diameters of boilers, all thicknesses of metal and all styles of joints; but the proof would be algebraical, and for this reason we have not thought it necessary to include it. Those of our readers who understand algebra will have no difficulty in finding the general proof for themselves, for it is based upon precisely the same considerations as the numerical example given above.—*The Age of Steel.*

Upsetting the Ends of Boiler Tubes.

Having had some experience in upsetting boiler tubes, I was surprised to learn that some manufacturers of tubes cannot overcome the difficulty of upsetting boiler tubes without leaving grooves in or outside the collars, as shown at *H*. I am working where boiler tubes are used by the carload; having examined some of them, I found grooves in them.

One day we were in a hurry for 400 boiler tubes, and as it would require a few weeks to get them from the East, our superintendent ordered them to be made at home. It was the first time we had made any; and, though there was a foreman in charge who knew the way of upsetting boiler tubes in the East, considerable difficulty was experienced in making them, and we also could not prevent the grooves forming.

Having solved the problem of upsetting boiler tubes without leaving any marks or grooves, I send you this drawing and description. The illustration at *C* shows the new header with swell or taper neck; it is for the first operation and expands



OLD AND NEW HEADERS FOR UPSETTING ENDS OF BOILER TUBES.

the tube as shown at *a*, Fig. *F*. The object of the expansion is to prevent grooves on the collars, as shown at *H*. *D* is the header for upsetting boiler tubes in the old way; it leaves grooves on the collars. This header can be used for the second operation, and leaves a perfectly smooth finish, as shown at *G*. *B* is the die with headers for both operations. *F* shows the collar after the first operation in the new way; *b* is the end of the collar—it is the same thickness the tube was before the first operation; *i* is the heavier part of the collar at the back. *G* is the finished collar after the second operation in the new way. *E* is the tube before the first operation. *H* is the collar showing the groove when made in the old way. *A* and *B* are the dies.

The advantage of the new taper header is not only the better and smoother finish, but also in the length of collar. With the old header (now used for the second operation) collars only up to 3 inches long could be made, while with the new or both headers, collars of 5 inches or longer can be made.

On a bulldozer or bolt machine, where the two headers can be adjusted for use at the same time, collars can be finished with one welding heat for both operations, if not over 3 inches long.—A. Z in *American Machinist.*

Pneumatic Tools for Boiler Shops—III.

Important Points on the Design, Operation and Care of Pneumatic Drills, Hammers and Hoists which are Used in Boiler Shops.

BY CHARLES DOUGHERTY.

Pneumatic Hoists.

As a necessary part of the equipment of boiler shops the pneumatic hoist has proved invaluable as a time and labor saver. These hoists may be classified under two headings, namely, the cylinder type and the motor type. The cylinder type, while readily answering many of the purposes for which the ordinary hoist is called into use, is nevertheless not as reliable as that operated by a motor-driven gear, and although some of them are equipped with devices for retention of a load, they have usually been found in practice to be inadequate for that purpose.

CYLINDER HOISTS.

Briefly, a cylinder hoist consists of a cast iron cylinder, or tube, in which a piston is fitted. The tube is suspended from the crane or support at one end, while the piston rod passes through a stuffing-box in the opposite end. The load is attached directly to a hook at the end of the piston rod, and the hoist is operated either by admitting air to the lower end of the cylinder or by exhausting air from the upper end while the lower end is under pressure. The height of the lift in this type of hoist is limited by the length of cylinder, and the capacity of the hoist or weight of the load which it can lift is limited by the air pressure and area of the piston. As a general proposition the control of the speed and travel of the piston is rather uncertain, and the hoist gives the best satisfaction when used to lift a load through the entire length of its stroke.

The hoist shown in Fig. 1, which is manufactured by the Quincy, Manchester Sargent Company, 114 Liberty street, New York, is always in a self-balanced condition, as the tank pressure of air is constantly on the lower side of the piston. To lift the load, the air from above the piston is released to the atmosphere, the escape being proportioned to suit the requirements of the speed of lift desired. To lower the load, the air is by-passed from the lower to the upper side of the piston, equalizing the pressure and the difference in areas of the sides of the piston, plus the weight of the piston and rod, cause the piston to be positively returned. By this method the air is used one way only, and a positively balanced machine is obtained. This hoist is equipped with two sets of chains for handling the load, one for the quick speed and the other for slow handling. When either chain is released a self-closing air-actuated valve closes, thus holding the load in position. The device for retention of the load consists of a friction collar on the piston rod connected to an auxiliary valve, and operating upon the slightest movement of the rod to replace

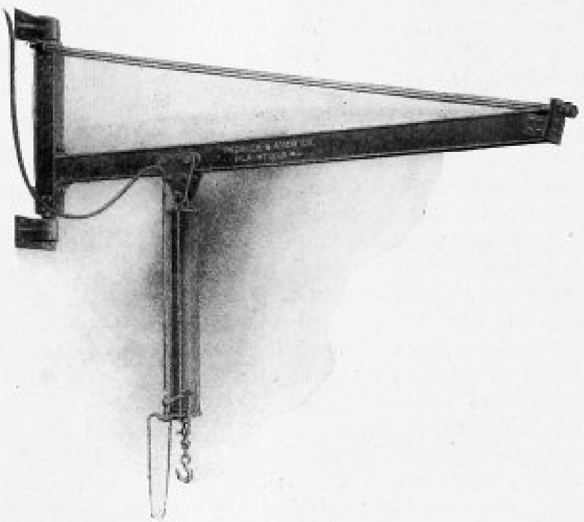


FIG. 1.—ORDINARY METHOD OF INSTALLING CYLINDER HOIST.

leakage of air from above or below the piston, and by this means sustaining the load at the desired height.

The heads on the cylinder of cylinder hoists may be either bolted or screwed on. In the hoist shown in Fig. 2, which is manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill., the heads are bolted on, and in general this arrangement permits easier removal when necessary. In this hoist friction is reduced to a minimum by having the cylinder highly finished and polished inside. The piston is provided with a cushioned stop at the top and bottom of the cylinder, to

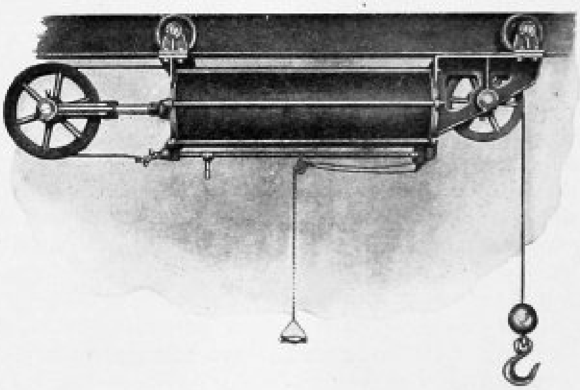


FIG. 2.—CYLINDER HOIST INSTALLED HORIZONTALLY.

obviate danger from sudden stops or jars. The valve is easy of access and can be removed without taking off the heads. Lubrication is obtained automatically and the exhaust is very efficiently handled by a special attachment.

The conditions of shop practice have brought about many different methods of installing cylinder hoists. The most common way is that shown in Fig. 1, where the hoist is suspended from a simple bracket or post jib crane. The crane, of course, swings about its support and the hoist can be moved along the crane in a radial direction. Fig. 2 shows a case where a cylinder hoist is installed horizontally. This arrangement is useful where it is necessary to save head room, since the distance from the support of the hoist to the top of the lift is reduced to a minimum. In order to obtain a longer lift the type of cylinder hoist shown in Fig. 3 has been devised, which is known as a telescopic hoist. In this case the single tube or cylinder is surrounded by a second tube, in which it is operated in the same manner as the piston and rod in the single

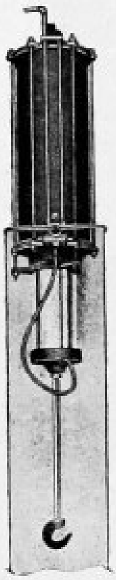


FIG. 3.—TELESCOPIC CYLINDER HOIST.

hoist. This type gives double the lift obtained with the ordinary type. Fig. 4 shows a common arrangement for a jib air crane. The cylinder is placed between the channel bars, which form the mast of the jib crane and operate the block and tackle through chains, which are suitably roved over pulleys so as to permit the trolley to travel back and forth along the jib. In Fig. 5, which is a combination pneumatic and hydraulic jib crane, the jib itself is raised and lowered instead of the hook. The mast of the crane is pivoted so that it can be swung about its axis.

MOTOR HOISTS.

While the simple cylinder hoist is particularly well adapted for certain classes of work its obvious disadvantages, such as the great amount of head room required, uncertainty of control, etc., have brought about the development of the motor hoist.

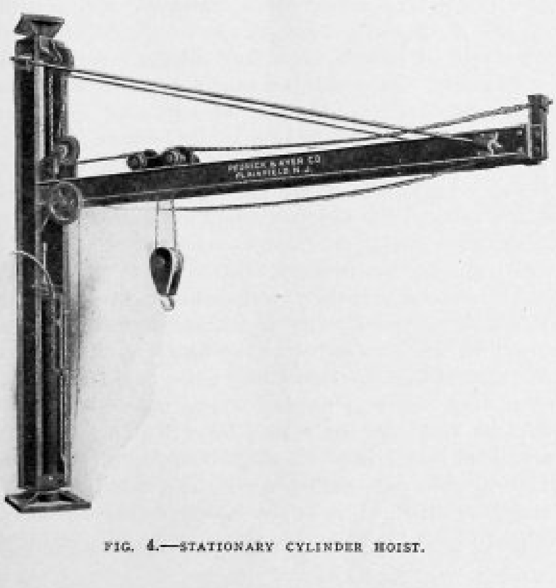


FIG. 4.—STATIONARY CYLINDER HOIST.

In this type an air motor is used to drive a rope drum, the motor being connected to the drum by a train of gearing.

Fig. 6 shows a hoist of this type manufactured by the Port Huron Air Tool Company, Ltd., of Port Huron, Mich., and known as the Piling Motor Hoist. It was first used in foundry work, but is now being used to good advantage in some boiler shops. It is of the oscillating cylinder type. The load can be

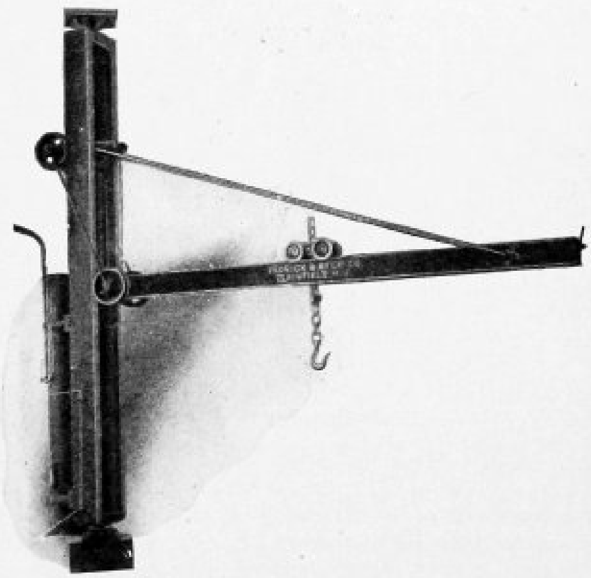


FIG. 5.—HYDRO-PNEUMATIC HOIST.

sustained with comparative safety without any appreciable settlement, by reason of leakage of air. The valve is operated by chains, reaching within a reasonable distance of the ground, allowing of instant starting or stopping of the motor. It closes automatically when the chains are released. There are eight ports, and when the engine is on the dead center the air is entirely shut off. Four of the ports on each cylinder head operate at the same time, allowing two to feed and two to exhaust, so that when the engine turns off dead center the feed and exhaust ports start to open. When the engine is on half-stroke the ports are wide open, and gradually close until it gets on dead center. The cylinder rocks on a trunnion pin, which is stationary, with a spring under the lock nut on the cover. The spring is made strong enough to take up all wear that may come on the two faces. The hoist is equipped with winding drum and wire rope.

Another hoist of the oscillating cylinder type is manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill. This is shown in Fig. 7.

The oscilliation of the cylinders opens and closes the ports. Lubrication is obtained by keeping a small quantity of oil in the case, which, when the motor is in motion, dashes oil on the valve seats, and is in turn carried by the air through the ports in sufficient quantity to thoroughly oil the pistons. It operates by the motor through a series of gears cut from solid steel. It is equipped with a friction brake, by means of which the load can be retained when it becomes necessary to hold it for any length of time, and thus the necessity of depending upon the air for that purpose with its constant dropping from leakage is avoided. The operating valve is self-centering, and is under constant control of the operator, who can readily adjust the speed by means of pendant chains provided for that purpose.

Fig. 9 shows a sectional view of a high-duty pneumatic hoist manufactured by the Ingersoll-Rand Company, 11 Broadway, N. Y. As can be seen from the illustration the motor drives the rope drum through a worm gear. This gearing instantly and positively locks the instant the

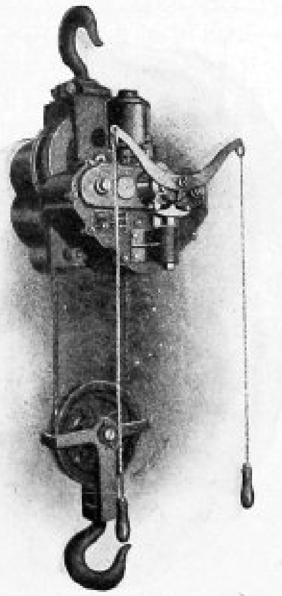


FIG. 6.—PILING MOTOR HOIST.

motor stops, whether in lifting or lowering the load, thus doing away with the necessity of a brake of any sort. This arrangement allows no possibility of slip or back-lash, even should the air pressure suddenly fail.

The motor is of the standard "Imperial" type—a balanced three-cylinder engine. The machine may be said to be "valveless," in the sense that no separate part is required for the control of the air distribution. Air enters and is discharged through the ports in the crank, which is of large diameter and so designed that the port passages are shorter than in any other piston motor. The three radial cylinders are bored from a single steel casting and rotate about the crank. The cylinder bearing about the crank is bushed with a taper bronze sleeve, and wear is taken up simply by driving up on the taper. The thrust of the pistons being always outward, and pressure being

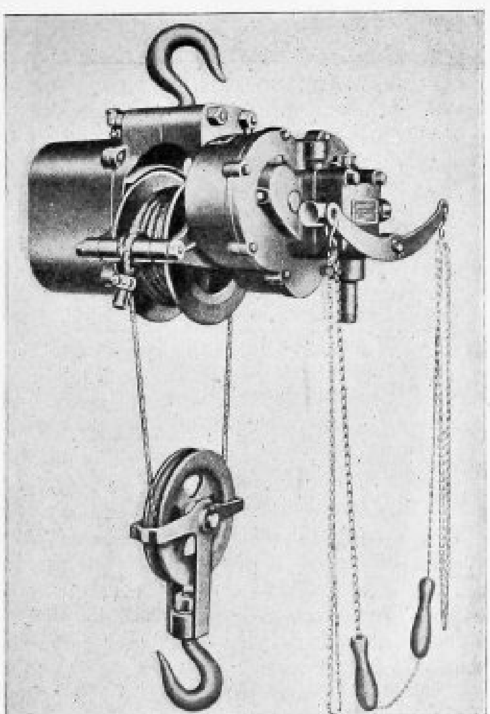


FIG. 7.—CHICAGO MOTOR HOIST.

always exerted between pistons and cylinder head, the cylinders are always forced down to a tight seat on the crank, and leakage of live air is an impossibility.

The motor casing is partially filled with oil which, in running, is thrown over every part of the machine. A glass-covered opening in the case shows the oil level. Every bearing thus runs in an oil bath. The casing is not under air pressure, hence there is no tendency to blow or force out the oil, a feature of great value in its effect upon good lubrication.

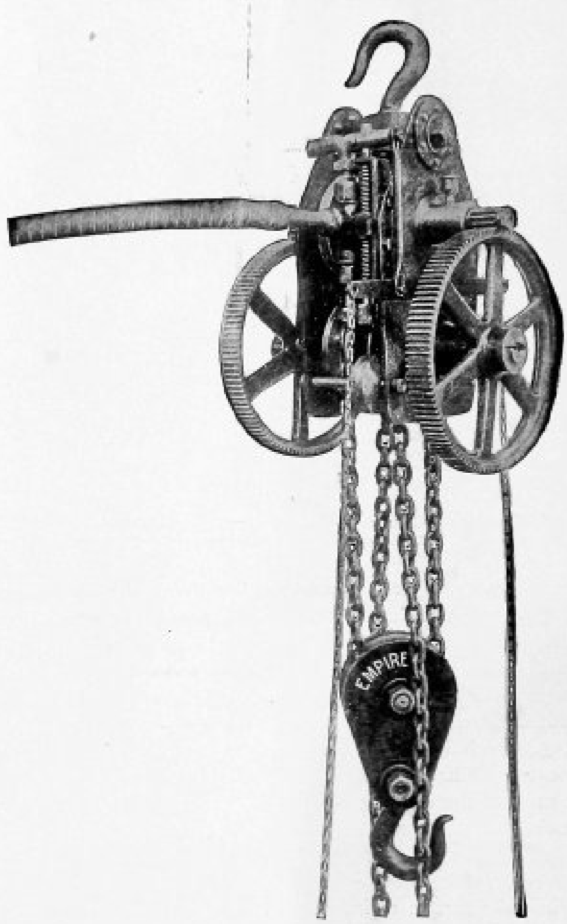


FIG. 8.—EMPIRE MOTOR HOIST.

The operating valve is self-centering and automatically returns to "closed" position when released. Pendant chains for control reach to the floor. An automatic stop is provided, which closes the throttle when the load has been lifted to the limit of safety. This little refinement prevents injury to the hoist through the carelessness of the operator.

Another feature of this hoist is the ball-bearing lower hook-block. The rope runs over a groove, permitting compensation in the two drums. The hook turns on ball bearings, and the load may be turned in any direction without twisting the rope.

The Empire Engine & Motor Company, Orangeburg, N. Y., has designed and constructed a motor hoist to meet the requirements of the advocates of a pneumatically-operated chain hoist. It is so constructed as to require little head room, while under perfect control of the operator it is possible to start, stop and hold the load at any point. Unlike the cylinder type of hoist, there is no dependence upon air pressure to sustain the load. As can be seen from the illustration, Fig. 8, a reversible motor is attached to the side plate. It has a pinion on each end of the piston shaft, which meshes into driving gear wheel, which in turn operates the main shaft upon which sprocket wheels are placed for the chain to run through.

They can be equipped with a friction brake, which permits of positive retention of the load.

(To be continued.)

Superheat and Furnace Relations.*

BY R. P. BOLTON.

In the application of superheat to any steam supply, a stable temperature or extent of added heat would appear to be a primary condition, but with the present forms of arrangements for the purpose this seems to be far from achievement.

A control of the temperature would in many cases be an additional advantage, and the attention of designers is evidently tending toward this feature.

It may therefore be of advantage to bring together some of the considerations bearing on this subject with a view to a more general interest in the methods of generating superheated steam.

Most of our present practice appears to be based upon the adaptation of superheating apparatus to standardized forms of boilers and settings, a leading consideration being the avoidance of disturbance of their accepted designs, or alteration of the accepted relation of boiler parts.

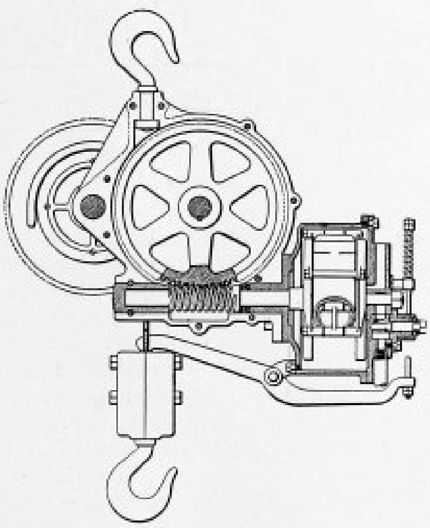


FIG. 9.—SECTIONAL VIEW OF IMPERIAL HOIST.

It has thus become very common practice to install superheating surface in some one position in the gas passages, where a more or less convenient space exists in a standard design, without special regard for its full desirability, or for a well adapted relation of the superheating surface to the path or travel, volume, or temperature of the gases.

Manifestly, if existing designs of boilers and settings are to be rigidly adhered to, this must be the case, but it would seem that the eventual aim should rather take the direction of a remodeling of the designs of both boiler and setting, in favor of the superheating apparatus, and that the latter should receive a greater consideration than its present very secondary position in the combination.

Merely to place a superheating coil in a certain part of the gas passage of a boiler, and to connect the steam supply to it by strange and undesirable pipe connections, as is so frequently the case at present, is by no means to be regarded as a complete solution of the problem.

In such a position, not only the design of the superheater, but often its true proportion may be sacrificed to the exigencies of boiler proportions, and its accessibility, so peculiarly necessary, becomes questionable.

* Vol. XXVIII, Transactions American Society Mechanical Engineers.

Placed thus, or in any other position where the travel of the main body of gases from the fire envelopes the heating surface, the superheater is subjected to conditions of wide variation of gas passage and temperature, largely increasing and decreasing its output in transferred heat.

If its proportions be based upon a given heat transfer to a given rate of steam passage through its interior, then the addition of green fuel to the fire, or other sources of heat variation there, may affect its output to a very wide degree, probably more than could be recorded by any thermometric appliance, and with consequent wide variation in cylinder effects.

The operation of an ordinary furnace is subject to so many variable elements in the nature of the fuel, its combustion, draft regulation, door openings, ash and clinker accumulations, and in the human elements back of all, that so sensitive an apparatus as that which is required to add heat to high-temperature steam should be protected as far as possible from these fluctuating influences.

Every engineer who has conducted boiler tests will agree upon the subject of gas fluctuations, in spite of the greatest care and expertness in hand-firing, and even to some degree with the use of automatic stokers.

The results would be comparable, though in a greater degree, to the inverse operation of condensing steam in a forced draft air system, in which the steam coil should be subjected to a draft varying considerably in volume, excessively in temperature, and being at the same time irregularly directed upon the tube surfaces.

It is not an answer in full to these conditions, to so construct a superheater, that an increase in the mass of material in its composition or in its walls or setting shall be provided, so as to absorb and give off heat to make up an average temperature condition.

Consideration in this direction should extend also to the furnace, and take the form of arrangements designed to eliminate the fluctuations of gas flow and temperature.

Automatic firing may do much toward such a result, but even more appears to be realized by the provision of some form of reverberatory construction, in which masses of brickwork in the form of arches or walls alternately absorb and give out excess heat.

Several recent modifications of furnace design appear to lead in this direction, and may evidently be productive of relatively beneficial results on the steam generating as on the superheating surface.

Arrangements are capable of combination with certain types of boiler settings, in which the superheater is provided with a separate gas flue from the fire, with a by-pass connection to some point in the main flue or passage beyond it, which by suitable dampers may be capable of a regulation of the volume of gas passing through the superheater. If provision could be practicably added for control of the gas volume by means of apparatus affected by the temperature of the gas, the output of superheat would become a defined quantity with a given steam flow, but with the high temperatures involved, this does not seem to be realizable.

Fluctuations in the steam output of the boiler would, moreover, still affect the degree of superheat, although this element is one that is partly controllable by existing apparatus, inasmuch as additions to the boiler output follow on additional furnace work, so that some modification or adjustment of the rate of gas flow over the superheater could probably be intelligently made by hand.

These considerations become more defined as the higher temperatures of superheat are attempted, and probably as much of the disappointment experienced in this direction is due to the lack of proper heat control, as to any other feature. The work of heat transfer becomes rather closely balanced when steam is being superheated to the high degrees frequently employed in Europe, and when gas of relatively high temperature is necessarily being utilized for the work. Such relatively high temperature may, upon a comparatively moderate disturbance of the furnace conditions, such as the introduction of fresh fuel, fall temporarily to the degree where very little heat transfer to the steam will take place, and thus the steam supply of a delicately adjusted engine is suddenly reduced very largely in temperature and its internal work, and its metallic expansion, much and undesirably modified.

It may not be too much to say, therefore, that for effectively securing the higher temperatures of superheat, the furnace conditions must be such as will eliminate the fluctuations of gas flow and temperature, or the heater must be placed where control of the gas volume can be secured.

As regards the maintenance of a given superheat at various outputs of steam, it may be said that where the relation between the furnace heat-output, the first heating surface of the boiler, and the superheating surface is well related, it seems reasonable to expect that variations in total steam supply would show little variation as regards the superheat, since the increase of furnace heat would be relatively absorbed by both the surfaces referred to. This would, however, be modified when higher degrees of superheat are in use, in which case less of the first boiler heating surface must be interposed between the fire and the superheater, and relatively less of an increase of heat would be absorbed thereby, subjecting the superheater to a relatively higher temperature, disproportionate to output.

Desirable results seem, on the face, to be more readily attainable in the separately-fired type of superheater, but in this form of the appliance the separate furnace is subject to many of the same effects of fluctuation, due to fuel, draft and handling, that a main boiler furnace would be. Moreover, the temperature at which the gases of a separate fire must pass off from the apparatus involve some loss in heat. This escaping heat might in some cases be utilized in an economizer, or as, in the recent proposal of Mr. Hosea Webster, member of the American Society Mechanical Engineers, these gases might be connected into the boiler gas passages at some suitable point, and be thus utilized in steam generation.

An ideal condition would, perhaps, be attained by a gas-fired independent superheater connected in this manner to the boiler, a refinement not, however, generally practicable, and thus for general practice it is necessary to rely upon the development herein advocated of the furnace control by such combination of grate, arch, walls, combustion chambers and draft as will to the greatest extent regulate the flow of heat.

The problem is one in which the designer and manufacturer of every type of boiler is interested, and which they cannot be too strongly urged to take in hand.

The evident trend of general steam practice is toward the use of some degree of superheat, and the boiler of the future may thus be regarded as a combined apparatus, involving fuel, air, furnace, generator and superheater, supplying with the same regularity and security with which commercially dry steam is now delivered, a superheated steam of defined quality in any quantity up to its extreme capacity.

Such a combination requires not only on the part of the designer but on that of the operator and user, some greater degree of attention and interest than has hitherto been bestowed upon the subject, and we may look forward to the time when the present methods of haphazard combinations of fuel, chimneys, grates, boilers and superheaters, often brought together without any co-relation, and even without any distinct object, will be exchanged for a policy in which the great boiler manufacturing interests will present, and the general body of steam users will appreciate, defined combinations of the furnace with superheating generators, developed from the information and experience which has been accumulating around the subject in recent years.

Layout of a Sketch Plate.

BY JOHN COOK.

In a sheet iron or boiler shop the layer-out is often confronted with a sketch similar to Fig. 1. One or more edges of the plate are in the shape of arcs of circles, the radius of which is not given; the only data given being the length and height of the circular segment, as shown in Fig. 1. In such a case the curve which forms the edge of the plate may be laid out as shown in Fig. 2. Draw the line *AB*, and at a distance from it equal to the height of the segment (in this case 6 inches) draw the parallel line *CD*. At right angles to these lines draw the

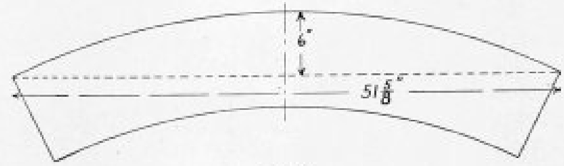


FIG. 1.

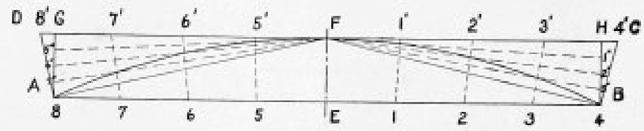


FIG. 2.

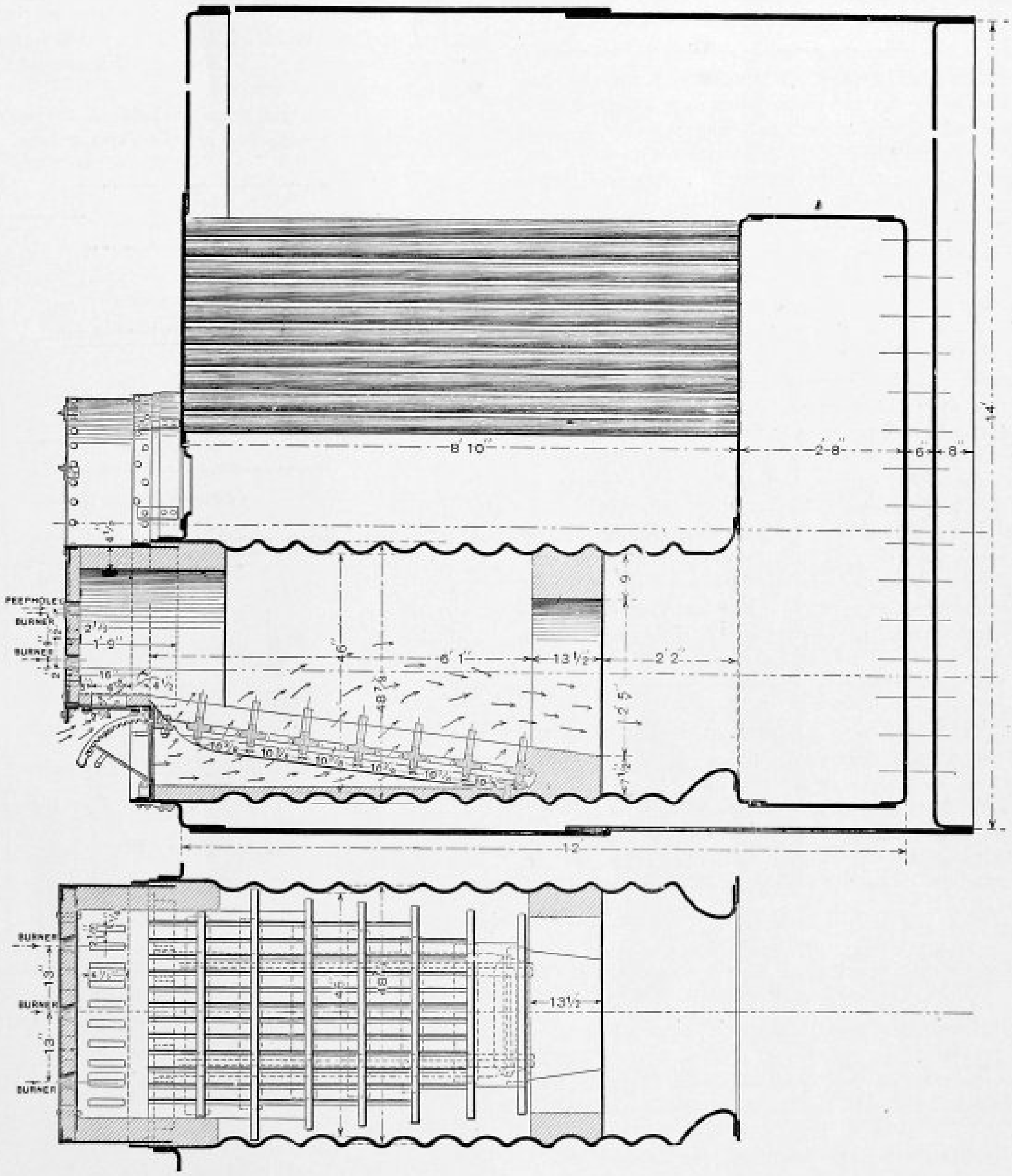
line *EF*, and on either side of *E* lay off half the length of the plate (in this case one-half of 51⅝ inches), locating the points *A* and *B*. Divide the line *AB* into any number of equal parts, in this case eight have been chosen. Draw the lines *FA* and *FB*. Then lay the square on these lines, draw from points *A* and *B* the lines *AD* and *BC*, intersecting the line *CD* at the points *D* and *C*. Divide the line *CD* into the same number of equal parts (eight) as *AB*. Also laying the square on either end of the line *AB*, draw the lines 4*H* and 8*G* at right angles to *AB*. Then divide the lines 8*G* and 4*H* each into four equal parts, or one-half the number of divisions into which the lines *AB* and *CD* were divided. Corresponding points have been numbered similarly in the figure to avoid confusion. Draw the dotted lines 1 1′ and *F*1″, the intersection of these two lines giving the location of one point on the desired curve. Draw the dotted lines 2 2′ and *F*2″. The intersection of these lines gives a second point on the curve, and in a similar manner the intersection of lines 3 3′ and *F*3″, 5 5′ and *F*5″, 6 6′ and *F*6″, 7 7′ and *F*7″ give the remaining points on the curve. Placing a flexible rod or batten on the points thus located, the completed curve may be drawn in. The remainder of the pattern shown in Fig. 1 may be completed by laying off the width of the plate at a sufficient number of points.

The problem of eliminating the smoke nuisance on locomotive and stationary boilers is one which principally concerns the operating engineer and fireman, since more can be accomplished in this direction by proper firing and intelligent operation of boilers than by changing the design and construction of the boiler. A number of devices have, however, come into use, from which advantages are gained in eliminating smoke. Since these effect somewhat the design of a boiler and its construction they are of importance to the boiler maker. Most common of such mechanical appliances are mechanical stokers, pneumatic fire-box door closers, hollow brick arches, and also such devices as strong blowers in the front end of locomotives and steam jets directed on to the fire through the fire-box side sheets.

Oil Burners in Scotch Marine Boilers.

A Scotch marine boiler of average length is a short boiler in which to burn oil. Its furnaces and combustion chambers, unaided by fire brick, are poor supporters of the combustion of oil vapors, however good heating surfaces they may be for coal fuel. Such are the advantages of using oil fuel, however, especially in the case of a tank steamer carrying a cargo of oil, that numerous devices have been introduced to make the ordinary Scotch furnace a successful oil burner.

The illustration shows a vertical section and also a horizontal section through one furnace of a Scotch marine boiler installed in the steamship *J. M. Guffey*, of the J. M. Guffey Petroleum Company. This is a 300-foot tank steamer with a capacity of carrying 45,500 gallons of oil. Although not originally intended for a tank ship, she was remodelled while under construction for this purpose. The fuel-oil tanks have a capacity of 332 tons, which is ample to run the vessel for a round trip between New York and Port Arthur, Tex. From the fuel-oil tanks the oil is first delivered into a cylindrical heating chamber, which forms a part of the foundation of the pumps which deliver the oil from the bunkers to the burners. This chamber is heated by the exhaust steam from the pumps. Steam passes in at the upper side and exhausts directly below at the bottom. In this manner the oil is heated to a temperature somewhat less than the temperature of the exhaust steam. The pump pressure put on the oil in the heating chamber is about 50 pounds per square inch and is automatically regulated by a pop valve located on the opposite side of the pump, which returns the surplus discharge to the pump suction.



SECTION OF SCOTCH BOILER AND PLAN OF FURNACE, SHOWING ARRANGEMENT OF OIL BURNERS.

There are two boilers in the ship, each 14 feet in diameter by 12 feet 2 inches long, with three furnaces each 46 inches in diameter. The total heating surface is 4,212 square feet. In each furnace of the boiler are five burners. The location of these burners at the mouth of the furnaces is indicated in the sectional drawing. The oil is atomized through the burners by steam at 80 pounds pressure. The diameter of the steam nozzle is ¼ inch; the diameter of the oil nozzle is 3/32 inch, and it is situated centrally in the steam nozzle, forming an annular steam opening about 1/16 inch wide. In this manner perfect atomization is effected with the smallest expenditure of steam, and combustion begins within the extension hoods on the furnace ends instead of at the rear of the furnaces. Natural draft supplies the air for combustion. The air is drawn through the lower part of the furnaces and passes partly through the highly heated brick-lined hoods and partly through the inclined brickwork forming the bottoms of the furnace chambers. It is thus thoroughly divided and heated before coming in contact with the vaporized oil, so that rapid and complete combustion is the result.

In order to secure complete combustion with the oil vapors as discharged from the burners, it is absolutely necessary that the temperature of the furnace be maintained at a high degree near the front where the oil enters. Therefore brick-lined chambers or hoods are fitted at the front of each furnace. In the plan view of the furnace the adjustable openings through which part of the air is drawn into these hoods are clearly indicated, as well as the construction of the inclined brickwork through which the rest of the air passes into the bottom of the furnace. This brickwork acts in the nature of a bed of hot coals for heating the air as it passes through.

The inclined bottom in this setting not only insures an entrance of air throughout the entire length of the furnace, but also increases the heating surface over that of the ordinary coal-grate setting and causes a higher temperature in the bottom part of the furnace near the combustion chamber. The tank over the bridge wall serves both to intensify the combustion, and to retard the gases so that there is no impinging effect upon the back plates and stay-bolts. The success of this installation is apparent from the fact that after about five months of continuous service the stay-bolts and flue-beads showed no signs of injury, while the flues were always clean and smoke was seldom, if ever, seen at the top of the stack. The furnace fronts can be easily removed for inspecting the boiler whenever necessary, and also all parts are easily accessible. The position of the fire-brick work makes it durable and prevents burning of the furnace castings.

For starting the fires in the main boiler, steam must be furnished from another source for the pumps and burners. For this purpose an upright 15 H. P. donkey boiler is used. Though no reliable data is at hand, the results from this installation seem to indicate a consumption of about 1.32 pounds of oil per indicated horsepower per hour, including all the auxiliary machinery.

Locomotives Using Superheated Steam Prove Exceedingly Satisfactory.

Mr. H. H. Vaughan's experience with locomotives using superheated steam, as related before the American Society Mechanical Engineers, has not been free from vexations and annoying troubles, but it has on the whole been exceedingly satisfactory.

The troubles encountered are being overcome as experience develops their cause, and the saving obtained is apparent in the reduction of the amount of coal used per ton mile on various divisions of the road as superheated locomotives are introduced. The additional capacity of the engines and the reduction of the work required of the firemen, enabling trains to be handled better, and the development of an engine which in extremely cold weather can be as easily maintained as a simple engine with an economy equal or superior to that of a compound is an important advantage to any railroad working in northern latitudes.

So far as can be seen at present there is no valid reason for discontinuing the application of superheaters, and the writer expects that a considerable increase in the number in use will take place in the next few years.

Strength of Riveted Joints.

BY J. C. BLACK.

A series of tests was made at the civil engineering laboratory of the University of California during the spring of 1906, to investigate the influence of some of the commoner defects in riveted work upon the strength of joints. As stated in the report of the tests published in the *California Journal of Technolgy*, no attempt was made to investigate efficiency or proportions, and the entire object of the work was the demonstration of the effect, if any, of certain features of riveted work commonly considered defects.

As shown in the tabulation of Table I, the tests included: 1. Well-made joints having punched and reamed holes; (2)

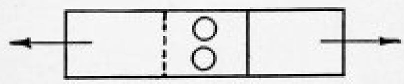


Figure 1

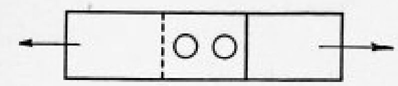
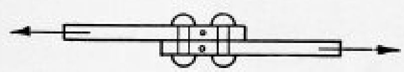


Figure 2



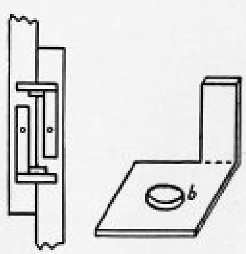


Figure 3

joints having holes punched without reaming; (3) joints in which the heads of rivets were cooler than customary when driven; (4) joints in which the heads were hotter than customary when driven; (5) joints in which the pressure on rivets was maintained longer than usual; (6) [no joints of this number]; (7) joints containing burned rivets, the rivets having been heated in the forge until they "spit" upon removal, then carried to riveting room and placed in regular petroleum heater; (8) one joint having extra large holes; (9) [no joints of this number]; (10) joints having holes eccentric. All plates were of ½-inch Carnegie "tank steel"; rivets were ¾-inch soft steel of Carnegie manufacture. Except where the contrary is stated (in the case of joint No. 8) holes were 13/16 inch in diameter. Riveting was done with an Allen pneumatic riveter. The fact that specimens were small and were held by hand while riveted, may have had the effect of reducing the quality of the work, since in large work the plates are held stationary, and thus afford better opportunity for a direct blow from the machine. In general, the rivets were driven by a single blow, and the pressure was maintained for only an instant.

The rivets were heated in a petroleum heater, and the scale was knocked from all before driving—a practice which is not always followed in ordinary work. Only lap joints were used, and each contained two rivets, although there were two designs or types of joint—the first being in the nature of a single-riveted lap joint, see Fig. 1, 2¾ inches center to center of rivets; and the second having the pitch line of rivets in the direction of stress, see Fig. 2, 2½ inches center to center of rivets. All joints were designed to fail in the rivets, although in some cases the plate itself gave way, at a point very near to what should have been the ultimate strength of the rivets. The edges of all joints were planed off near the center to allow the proper attachment of brackets for deformation measurements. In the first type of joint the holes were drilled in each edge of each plate just opposite the rivets, see Fig. 1; stopping the machine except in the special cases noted. The curves here shown indicate in a very satisfactory manner the behavior of each joint. Many of the specimens bent to a certain extent before failure. Rivet failure was always in shear, giving silky fracture. Table I gives in a condensed form the data obtained from the tests. It shows, first of all, a wide variation among each of the various quantities, and it is now regretted that tests were made on so large a variety of specimens, as a larger number of tests on joints of one or two kinds (with, of course, well-made joints for standard) would have been of greater value.

Table No. 1.

Tabulation of Tests.

Joint	Characteristic	Holes	Style	Failure	First Slip lbs	Yield Point lbs.	Ultimate Str. lbs.	Amount of F. S. in.	Deformation at F. S. in.	Deformation at Y. P. in
1A	well made	P&R	k	r	7 000	31 000	48400	.0097	.0013	.0230
1B	well made	P&R	l	r	12 500	29 500	48 600	.0050	.0025	.0140
2A	well made	P	l	p	24 000	37 000	47 750	.0035	.0015	0110
2A"	well made	P	K	p	15 000	32 500	54 000	.0060	.0020	.0210
2B	well made	P	K	r	14 000	32 500	58 650	.0080	.0020	.0255
2B"	well made	P	l	p	15 000	36 000	54950	.0010	.0015	.0170
2C	well made	P	l	r	15 000	34 000	53800	.0070	.0020	.0170
3A	cool heads	P	K	r	18 000	29 000	53000	----	.0030	.0135
3B	cool heads	P	l	p	22 500	32 000	53 000	.0043	.0022	.0135
3C	cool heads	P	l	p	20 000	36 100	54 150	.0073	.0012	.0130
4B	hot heads	P	l	p	18 000	34 200	51 100	.0080	.0040	.0210
4B"	hot heads	–	K	r	6 000	26 500	54600	.0050	.0008	.0115
5A	pressure held 30 seconds	P	K	r	24 000	36 500	58 150	.0048	.0022	.0095
5B	"	P&R	l	r	23 000	37 500	52 000	.0030	.0025	.0105
5C	pressure held?	P&R	l	r	26 000	39 500	-----	.0027	.0033	.0140
7A	burned rivets	P&R	l	r	10 000	30 000	51500	.0115	.0005	.0175
7B	burned rivets	P&R	l	r	12 500	34 000	48700	.0040	.0030	.0185
8	15/16 in holes	P&R	K	r	10 000	38 500	57300	.0073	.0007	.0240
10A	holes eccentric 1/8 in	P	K	r	9 000	28 000	53400	.0100	.0015	.0190
10B	" " 1/4 in	P	l	r	18 000	31 200	50500	.0097	.0035	.0210
10C	" " 1/4 in	P	l	r	20 000	28 000	45900	.0070	.0035	.0160
10D	" " 1/8 in	P	l	r	20 000	36 000	52100	.0045	.0030	.0235

the holes were tapped to receive a No. 8 screw. In the second type, holes were drilled midway between rivets, see Fig. 2, and were tapped as before.

The tests were made in a 200,000-pound Olsen machine, and deformations were measured with an Olsen compressometer. After the joint had been clamped in the jaws, and the planed edges brought into a vertical position, brackets were screwed to the edges as indicated in the sketch, see Fig. 3. Each bracket contained a small, accurately finished brass plug, marked (*b*) in sketch, and upon which the points of the compressometer arms rested. It can be seen from the drawing that when a tensile force is applied to the joint the plugs (*b*) will be drawn toward each other.

Loads were applied as shown in the plots, in increments of 1,000 or 2,000 pounds, and the test carried to failure without

Curves plotted from the results showing the deformation for different loads indicate very plainly the three periods so frequently mentioned by writers on this subject as being manifested in a joint as it passes from a state of zero stress to failure. First we have the period in which the deformation is small and is practically proportional to the stress; second, comes the period of sudden or marked slip; and third, the period in which the joint recovers its strength, and again has small deformation per unit stress. The period continues until the yield point is reached. If we wish to add a fourth period we may include that extending from the yield point to rupture. The curves further show that what I have designated as the "first slip" is not a sudden slipping over any appreciable distance, and, in fact, there seems to be no such sudden slip at any point within the range of readings taken. The ratio of stress to strain is merely less during this period. The beginning of the first slip, or second period, probably marks the point at which the rivets come to bear directly on the plates. We find from the table that with one exception, the first slip commences at considerably lower values in joints of the single-riveted type than in other joints of the same serial number, and having rivets in the line of force. We also find that the amount of first slip was greater in the joints first mentioned than in the latter. Among the other quantities there seems to be no such regularity, one of the joints being affected more in one case and less in another. The style of joint should not in the present case affect the ultimate strength, since long before this point is reached, both rivets would be in full bearing. This point is amply proved by the fact that with the exception of joints

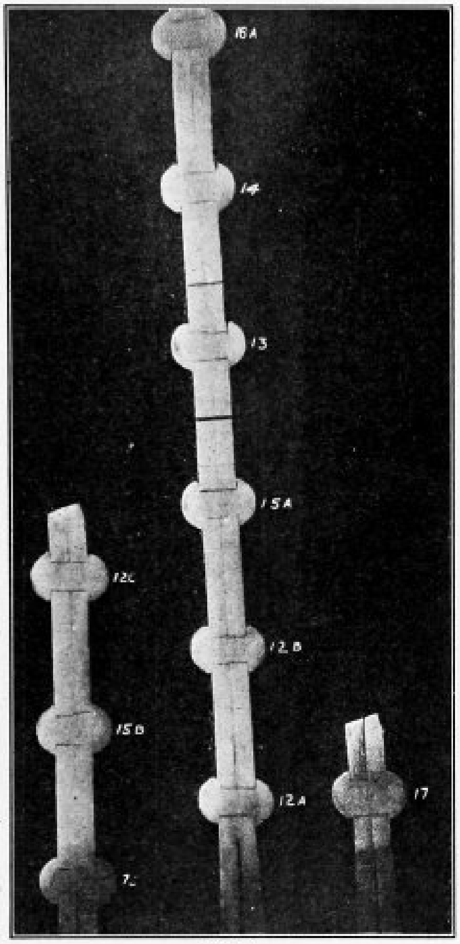


FIG. 4.

having eccentric holes, both rivets broke suddenly and together.

Contrary to what was expected, it is noted that deformations are generally greater, and the stresses at the various points less for joints having punched and reamed holes than for those in which the holes were punched full size. When reaming was done, the holes were punched 11/16 inch and reamed 13/16 inch.

The results of tests on rivets driven with cool heads do not warrant any very certain deductions. They seem to indicate, however, that there is little, if any, difference between this class of work and the ordinary. The same may be said of those in which the heads were hotter than the points.

The joints in which the pressure had been maintained 30 seconds on each rivet showed more definite results, and judging from the table we may infer that this proceedure decreases deformations and raises the point of first slip, yield point, and ultimate strength. The stress at the point of first slip is increased by about 40 percent, and that at yield point by about 8 percent. Although these results are quite marked, the maintenance of pressure for the time of 30 seconds would doubtless be found poor economy in any work except where some special feature demanded the utmost strength from each rivet. It is quite possible, however, that a maintenance of pressure for a period much less than 30 seconds, and still longer than customary, would have a beneficial effect, and this point should be investigated.

In the case of joints made with burned rivets, the stress at first slip was a little low, but there were no features of marked variation from the well-made joints.

Joint No. 8 (having ¾-inch rivets and 15/16-inch holes) gave high yield point and ultimate strength, which was to be expected, as the rivet metal would be forced into the holes in driving, thus increasing the cross-section of metal to be sheared. The strength of such work where the joint would be subjected to vibrations or other stress than simple tension, would probably be considerably diminished, since rivet heads were in this case small, owing to driving of the metal into holes.

The joints having eccentric holes gave large slips throughout, though the ultimate strength was high, and the yield point but little lower than normal. In two cases these joints failed in one rivet first, the other holding for some time at about its single shearing value. It was desired to find how the rivets filled the holes and the nature of the contact in the various cases, and with this end in view a number of rivets were driven in strips of plate, and the plates then sawed down, cutting the rivets not quite to the center. On the sawed surfaces the contact seemed to be very close, and in some places it was impossible to find the line separating rivet and plate. The surfaces were afterwards planed off and then polished, and this brought the spaces between pieces of metal plainly into view.

The photograph, Fig. 4, shows very clearly the various contacts. The closeness of that between plates is noticeable. The plates were painted before riveting. The dark lines between rivets Nos. 13 and 14, and between Nos. 13 and 15A, as well as the striations on No. 17, were defects of finishing the surface, and have no bearing on the riveted work itself. All of the holes in these cut specimens were punched and reamed. No. 7 was a rivet burned until "spitting," and then driven; No. 12A was ordinary work struck three times; Nos. 12B and 12C were struck twice each, each blow being nearly instantaneous; No. 13 was a rivet whose head was almost black when driven, it was struck twice; the head of No. 14 was extra hot when driven, it was struck three times; No. 15A was driven in the ordinary manner with the exception that the pressure was maintained 15 seconds; on No. 15B the pressure was maintained 20 seconds; the rivet in No. 16A was extra hot all over, it was struck once; No. 17 was a ¾-inch rivet driven in a 15/16-inch hole, and was struck three times. The results show that the contact in the case of rivets struck two or three times is good, and that it does not seem to be materially improved by the maintenance of pressure for 15 seconds. The rivet whose head was cool gave poor contact, though such work in the test proved as strong or stronger than ordinary. The rivet driven with an extra hot head developed a good and uniform contact, although it had been expected that the part of the hole near the point would be imperfectly filled. The rivet driven extra hot did not appear to have as good a contact as some of the others, though this may be due to the fact that it was at the end of the plate. No. 17 (the ¾-inch rivet driven in 15/16-inch hole) was noticeably loose. The burned rivet gave a rather poor contact.

Joints Nos. 1B, 2B, 3B, 5B and 10B were tested in repeated stresses as follows: After the stress had reached a point near 10,000 pounds, it was removed by running the machine back, and the test recommenced from zero. After reaching a second point higher than the first, the stress was again removed, and this process was repeated several times. The results are shown in detail by the dotted lines in the plots. These results show that in every case, a permanent set occurs even for loads not exceeding 10,000 pounds, and from the manner of attaching apparatus, it would seem that the only deformation registered must be that of the slip of the joint. Hence we infer that there is a slip at all loads, but that there is also a tendency to recover, even before reaching the point of first slip. The partial recovery would be expected after the first slip was passed, since we judge that the rivets are then bearing on the plates and their elasticity would come into play. Just why there should be even slight recovery before reaching this point is not entirely clear, since friction is supposed to be the only force acting.

Three rivets were tested in double shear. They had not been heated and were just as taken from the keg. It will be noted that since they were in double shear, each should give an ultimate strength about equal to that of one joint. The three double shearing values were 41,480 pounds, 38,820 pounds, 38,970 pounds (average 39,760 pounds).

We may now sum up the results of the whole series of tests and examinations of cut sections. We have no positive proofs of the various points, but the indications are as follows:

First. That the strength of rivets in a joint having holes punched without reaming is greater, rather than less, than in one in which holes are punched small and reamed to size.

Second. That the exact temperature of the rivet or of a particular part of it is immaterial to the strength of the joint.

Third. That a maintenance of pressure for 30 seconds materially increases both the strength and rigidity of the joint —the first sometimes by as much as 40 percent.

Fourth. That rivets burned so that they spit when taken from the fire do not necessarily cause a weakness in the joint, although they do not properly fill their holes.

Fifth. That a rivet 3/16 inch smaller than the hole which it is to fill, will fill the space tolerably well though not perfectly.

Sixth. That joints in which the holes are not perfectly concentric lack rigidity, but give ultimate strengths about up to standard.

Seventh. That the shearing value of a rivet is materially greater after driving than before, this probably being due to increased cross-section.

Estimating the Horsepower of Boilers and Engines.

BY A. S. ATKINSON.

In estimating the horsepower required for any given plant the owner frequently makes the mistake of not taking into due consideration the relation existing between the boilers, engines and grate area. Purchasing a boiler of a given rated horsepower, and then finding that it does not come up to the requirements, produces ill feeling and injures both manufacturer and owner. It does not follow that there has been any misrepresentation on the part of the makers, for the boiler under given conditions will fill the contract, but the owner has not carefully considered certain facts which are of prime importance. A good boiler harnessed to a poor engine cannot give good service, and insufficient grate area or poor fuel will make the best of boilers inferior in operation. A practical engineer engaged in installing steam plants should be thoroughly familiar with all of these features.

The flexibility of the modern rating of the horsepower of boilers is apparent to engineers, and there is a good reason for it. Usually a safe margin is left in designing a boiler for a plant. This margin of safety is seldom placed lower than 10 percent, and often it approaches 20 percent. Thus, if a 70-horsepower boiler is needed at least 80 horsepower is considered essential to make allowances for the difference between the commercial rating and actual output in operation. A 50-horsepower engine can be operated by a 55-horsepower boiler, but in many cases a 65-horsepower boiler is ordered for the work.

The external dimensions of a boiler do not decide the output. Unless the number of square feet of heating surface is taken into consideration there is pretty sure to be trouble. A 55-horsepower boiler with 700 square feet of heating surface is manifestly more economical and satisfactory than a 65-horsepower boiler with something less than the same amount of heating surface. In external dimensions the two may be exactly alike, occupying the same amount of space. The difference between these ratings is found in the unit of surface required to produce 1 horsepower. This unit differs all the way from 10 to 13 square feet. If the former unit is chosen it is quite evident that a much larger output can be obtained in figures on a smaller total area of heating surface. For this reason it is quite important in buying a boiler to know the number of square feet of heating surface supplied and the unit of surface used in computing the commercial horsepower output. When a low unit is used the boiler may be able to produce the full horsepower, but it will be accomplished only under forcing. The best of fuel must be used and the fire must be forced continually. The result is that unless a wide margin of safety is left the plant will prove unsatisfactory and unequal to the work required of it.

It is a common fact that the unit of surface equivalent to 1 horsepower varies a good deal in the different types of boilers and also in individual boilers of each class. The only safe method is to use a different unit for measurement in the horizontal boiler, the locomotive and all other types.

The next point to consider is the engine itself. The amount of steam required to produce 1 horsepower varies a good deal in different engines. The size and style of the engine must be carefully estimated before the boiler is selected. The fact that engines differ so materially makes engineers very conservative in stating the size of boiler required to operate them. If the engine is rated at 50 horsepower, the size of the boiler required runs all the way from 40 to 55 horsepower. If the engineer is familiar with the unit of measurement used in computing the horsepower of the boiler he can come fairly close to estimating the size required.

To make an ideal combination of boiler and engine it is essential to know the dimensions of the boiler, its capacity for generating steam, the square feet of heating surface, and the weight of steam required for the engine to be coupled with it. The former points are obtained by a careful study of the unit of measurement and the type of the boiler. The latter must be obtained from the amount of steam consumption per horsepower. This may vary all the way from 20 to 32 pounds. Engines are even more variable in their output than boilers, and their connection with boilers is something that needs a good deal of technical knowledge. A boiler capable of evaporating a certain amount of water to furnish steam for a 50-horsepower engine, which consumes 20 pounds of steam per horsepower-hour, can show unusual economy and efficiency of operation, but if the steam consumption is 28, or even 32, pounds per horsepower-hour the output of the boiler is measurably decreased.

It is quite common to lay the blame for an inefficient plant upon the boiler and not to consider the engine. For instance, a plant in which a boiler of 100 horsepower was installed, and which had received its rating by using a low unit of surface measurement, had an old type of engine which took 32 pounds of steam per horsepower-hour. Instead of developing 45 horsepower in the engine as expected it was barely possible to get more than 40 horsepower, and even that was obtained only by forcing the fire. The boiler was condemned by the owners, and they thought they had been deceived by the manufacturers. It was only after a good, practical demonstration that the owners were induced to change the engine. A new type was installed, and the immediate result was that over 60 horsepower were obtained. The fault all along had been in the engine, and not in the boiler.

It is a peculiar and important fact not always recognized that when the steam consumption of the engine increases the actual horsepower of the boiler decreases. It apparently refuses to carry the double load, and the poorer the engine the less actual service will the boiler do. A boiler capable of developing 50 horsepower when coupled to a good engine with low steam consumption will often decline to a 45-horsepower in actual operation. This close relationship between the two indicates emphatically the necessity of selecting the engine with as much care as the boiler.

The proper proportioning of boilers to engines is a particular piece of work. One of the best ways is to allow at least 11 to 12 square feet of heating surface of the boiler for each rated horsepower of the engine of the four-valve non-condensing type. But to assume this same proportion for other types of engines would prove fatal to good engineering practice. For the single-valve automatic cut-off engine there should be allowed at least 12 square feet of heating surface. A still further increase must be allowed for throttling engines. As high as 14 to 15 square feet must often be allowed for this type, owing to the possibility of the engine working beyond its rated power.

It is common sense applied to engineering to make a thorough technical study of each individual boiler and engine before arriving at any definite capacity of work, and it is by taking sweeping generalizations of rules without regard to the actual conditions of the case that so many troubles appear. The capacity of the boiler is expressed in pounds or the probable evaporation from 212 degrees per hour, but the capacity of the engine is somewhat different. It is common in general practice to assume that a single-valve non-condensing engine will average 30 pounds per horsepower-hour, but any test of a number of such engines will show that there is quite a variation in this. Some average much less consumption and others more, depending upon the design of the engine. Likewise for a four-valve engine, 26 pounds of steam are allowed per horsepower-hour, and for the compound type only 22 pounds. Condensing engines take from 10 to 15 percent less, and they are, therefore, more economical and efficient in their operation.

Suppose a well-designed boiler is chosen for its work with any of these different types of engines. It is quite apparent that its capacity will vary as greatly as the consumption of steam does by the different engines. If a 100-horsepower boiler is used with a single-valve non-condensing engine the output will be about as rated, but if a compound engine consuming only 22 pounds of steam per horsepower-hour is used the horsepower will equal 137. Therefore, the relation between the boiler and the engine will prove so close and important that an enormous saving may be obtained or a daily loss sustained with the same boiler. The fault is not with the boiler but with the engine.

In another way the capacity of the boiler and its efficiency depends upon the grate and the fuel burned. It cannot produce its highest generating capacity unless heat in the furnace is properly developed. With inferior coal the full capacity of the boiler cannot be obtained except by forcing and constant feeding. If the grate area is insufficient it will be impossible to generate sufficient heat at all points of the heating surface to obtain a maximum generation of steam. The necessary quantity of fuel required to produce a given evaporation of water must be taken into account. The several formulas adopted for ascertaining this fact do not always give an exact result. The ratio of the heating surface to the grate surface must be exactly ascertained, and also the weight of the coal burned per square foot of grate surface per hour. It is possible by using these quantities in a formula to obtain the maximum evaporation that can be reasonably expected under favorable firing conditions. This maximum is often used in selling boilers, so that the man who does not leave a safe margin is apt to meet trouble. An engineer making such estimates is always careful to distinguish between the maximum possibility and the actual. Few boilers come up to the maximum, and it is a great mistake to figure on such a basis. It is here that so much trouble is caused by not making allowances for the difference between the commercial and actual horsepower of any boiler.

The effect which the nature of the coal has on the boiler's capacity may be illustrated in a typical case. If in figuring on a boiler the weight of the coal used is put at 30 pounds the capacity is nearly doubled if the weight is placed at 15 pounds. It is possible to make such a difference in the very best and very poorest coal, but in ordinary steaming work no such variation would be apparent. In regions where a very high grade, heavy coal is the common fuel, it is possible to get the maximum work out of a boiler without trouble, and the boiler may be much smaller than another used where a low-grade fuel must be burnt. There is quite an item of economy found in this adaptation of boiler to the fuel in use. In installing a new plant with boilers the first question to be settled should, therefore, be the kind of coal that will be used.

Fourteen to 15 pounds of coal per square foot of grate surface are commonly figured upon in many parts of the country where hand firing is done. With mechanical stoking and good firing this may be decreased to 11 to 13 pounds. Forced draft always changes the conditions and makes quite an important variation in the efficiency of the grate and boiler output. The flexibility of the boiler, the engine, and the grate and coal is a matter which involves the whole estimate of the horsepower of a plant in a technical study. It is not easy for one not thoroughly versed in all these matters to choose a boiler and engine without making some mistakes.

Punching Boiler Plate.

Punching the rivet holes in boiler plate is not considered good workmanship, both because the holes cannot be accurately located in this way and because the action of the punch and die injures the metal. Most punches are provided with a small tit or projection by which the punch can be centered in a center punch mark made by the layer-out at the proper location of the center of the rivet hole. This is supposed to secure the accurate location of the hole, but in practice it is an easy matter for the punch to slip a little off center, especially when the work is being run off rapidly, then when the plates are bolted together the holes will not match fairly.

The metal around the rivet hole is injured in two ways. In the first place it is made brittle, and in the second place the shape and action of the punch and die cause it to be left in a torn and ragged condition, and the hole itself is of such shape that it is hard to make a rivet fill the hole completely and make a steam-tight job. The ordinary form of punch and die is shown in Fig. 1. The diameter of the end of the punch is usually 1/16 inch larger than the diameter at the top, while the diameter of the top of the die is 1/32 inch larger than the diameter of the end of the punch. Although these are standard dimensions, they are sometimes varied, and it would be well to know how changing the form of a punch affects both the effort required to punch the hole and the material which is being punched.

When a punch similar to the one shown in Fig. 1 is brought into action a certain effort or force is required to drive the punch through the metal. Since the separation of the metal is due to the shearing action between the edge of the punch and the edge of the die, the force required to drive the punch through the plate is easily calculated by finding the area of the section of plate which is sheared and multiplying this by the shearing strength of the material. The area to be sheared has a length equal to the length of the circumference of the end of the punch and a width equal to the thickness of the plate. Thus with an inch punch and 3/4-inch plate the force required to drive the punch through the plate equals $3.1416 \times 1 \times 3/4 \times 42{,}000 = 98{,}960$ pounds.

Experience has shown that by the time the punch has been forced one-third of the way through the plate the metal is entirely sheared off, so that the entire effort required to punch the hole is expended through a very small part of the stroke of the punch, and during the remainder of the stroke the only effort required is that necessary to push the punching out through the hole. This shows the necessity of having a heavy fly-wheel on the machine. Sufficient energy must be accumulated by the fly-wheel during the greater part of its

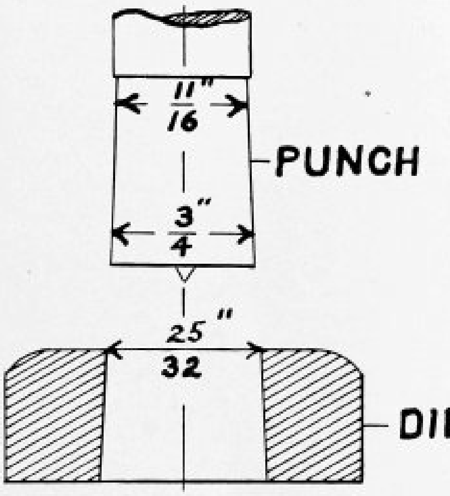


FIG. 1.

stroke, so that the force expended in punching the hole will not decrease its speed to such an extent that it cannot pick up enough energy to punch another hole on the next stroke.

Since the metal is entirely sheared off by the time the punch has passed only a third of the way through the plate, it is evident that the metal cannot have been cut off smoothly, and the rough, jagged appearance of the hole shows that this has not been the case.

In light plates this effect is not so apparent, and the hole is fairly smooth from the side from which the punch enters, where the hole will have a diameter equal to the diameter at the end of the punch, down through to the under side which rested next the die in the machine, and which will have a diameter equal to the diameter of the top of the die.

In thick plates the diameter at the top of the plate where the punch first enters would be equal to the diameter at the end of the punch, and the diameter on the underside of the plate which rested on the die will be the same diameter as the top of the die, but in the middle of the plate the metal will have torn out so that the diameter *D"* (Fig. 3) will be greater than either *D'* or *D*. Figs. 2 and 3 show the effect of punching holes in both light and heavy plate.

Punches are sometimes made of the form shown in Fig. 4, in order to distribute the effort required to punch the hole through a longer part of the stroke of the punch. The end of the punch, which is tapered to the width *B*, enters the plate first, and offers only about one-quarter the resistance of the entire punch. By the time the punch has penetrated the plate the distance *A*, that is, until it is punching the full size hole, which would represent the greatest effort required, the metal under the section *B* has been almost entirely sheared away, and therefore the force necessary to drive the punch through

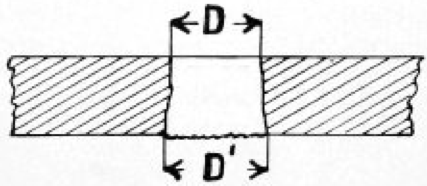


FIG. 2.

the plate rapidly falls off, and for the remainder of the stroke the effort diminishes rather than increases.

The form of standard punch shown in Fig. 1 works very well when the punch is new, but if the punch is slightly worn it will begin to bind, and in addition to the resistance offered by the shearing of the metal under the punch there will be a

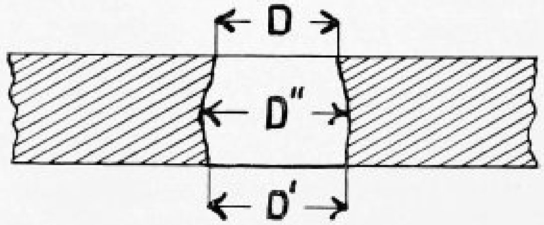


FIG. 3.

certain additional resistance due to the side pressure of the punch in the hole. In order to obviate the effect of this side pressure the punch shown in Fig. 5 is sometimes used. The sides of this punch are parallel to within a short distance of the end of the punch, when it is flared out to the required diameter or 1/16 more than the body of the punch. It is evident that there can be no side pressure on this style of punch.

It might well be asked what effect will be made in the hole by varying the relative sizes of the punch and die. We have

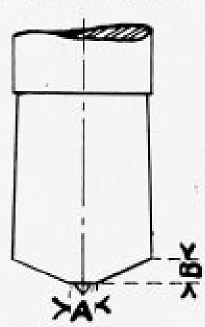


FIG. 4.

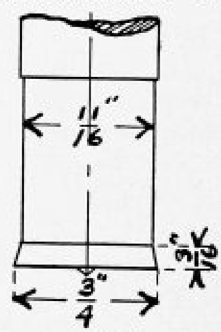


FIG. 5.

seen that the usual custom of making the die 1/32 inch larger than the punch gives a tapered or cone-shaped hole and on thick plates leaves a ragged edge. Could this not be obviated by making the die smaller or larger?

Making the die smaller greatly increases the effort necessary to punch the hole and shortens the life of the punch. Therefore, although a better hole would very probably be obtained, it is hardly possible to use a smaller die. Increasing the size of the die would lessen to a certain extent the effort required to punch the hole and would prolong the life of the punch, but at the same time it would exaggerate the taper of the hole and tend to leave the metal in a more ragged and rough condition than before.

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.

The edition of this issue of The Boiler Maker comprises 5,500 *copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

The Cost of Boiler Construction.

The attention of those who are accustomed to uphold the dangerous lap-jointed boiler on account of its cheapness, is invited to the article published elsewhere in this issue on the subject of estimating the cost of a return-tube boiler. This article gives a complete analysis of the cost of a boiler of this type designed for a certain pressure, first when it is constructed with a lap-jointed shell, and second when it is constructed with a butt-jointed shell. It is found that by using a butt-jointed shell the thickness of the shell plate can be reduced sufficiently so that the smaller first cost of the lighter shell more than offsets the extra cost of the added work on the butt-strap joint, and that the total cost of a butt-jointed shell is less than that of a lap-jointed shell.

This Means You.

During the coming year we expect to devote much more space than heretofore in each issue of THE BOILER MAKER to the publication of items of personal interest regarding boiler makers throughout the country. As we must necessarily depend upon our readers for much of this news, we trust that all who take any interest in the doings of other boiler makers will help us make this department as complete and interesting as possible by sending us each month a number of items regarding any change of location or business or of promotions, etc., of either themselves or any of their friends who are connected with the boiler making industry. In connection with this we also wish to urge our readers to contribute more freely to the columns of our magazine, by sending us from time to time short articles describing any interesting or unusual work, methods of doing the work, or improved machinery and tools which they are using; queries regarding subjects on which they would like the opinions of others, and discussion on the many live topics which are presented by others. The preparation of such short articles requires practically no time, since it is necessary to send us only the essential details and specifications, together with such sketches, blue prints and photographs as may be necessary to illustrate the article. All such contributions are always paid for promptly upon publication at our regular rates.

A Much-Needed Change.

In the annual revision of the general rules and regulations prescribed by the Board of Supervising Inspectors of the United States Steamboat Inspection Service for the construction of marine boilers this year, an attempt is to be made to change the rule governing the allowable working pressure to be carried on boilers. At present the rule provides that the working steam pressure must not produce a stress in the shell of the boiler to exceed one-sixth of the tensile strength of the material of which it is made when the longitudinal seam is single riveted, but when the shell is double riveted and all holes are fairly drilled, 20 percent may be added to this pressure. This rule practically disregards the strength of the riveted joint in the boiler shell, a sufficiently large factor of safety being provided to allow for the weakness at the joint. A steam-tight single-riveted joint cannot be designed which will have much more than 50 or 55 percent of the strength of the solid shell. Including such a value in the computation for the safe working pressure of a boiler for which the pressure has been determined by means of the present United States rule we find that the factor of safety is really only about 3.5. Similarly with the double-riveted joint, if it is to be steam-tight, it is impossible to design a joint that will be much more than 70 percent as strong as the solid shell, and if this value were used in the computation it would again be found that with the 20 percent additional pressure which is allowed for the double-riveted joint in accordance with the present marine law, the factor of safety would again be about 3.5.

It is apparent that this is a needlessly indefinite and inexact rule for determining the safe working pressure of a boiler. The strength of any riveted joint, as compared with the solid plate, can be readily calculated. Therefore, since the strength of the joint can be accurately determined, it is absurd not to include this value in the computation for the strength of the boiler. If due allowance has been made for the weakness of the joint in the shell, then a proper factor of safety may be used, and it will be known that this factor represents exactly the difference between the safe working pressure and the bursting pressure of the boiler. Also, the added advantage will be gained that any strength added to the boiler by the use of an exceptionally strong joint will add directly to the working pressure allowed on the boiler.

It is expected that this rule, as amended for 1908, will take account of the foregoing facts and that in addition to this a definite and complete rule or set of formulæ will be given for determining the strength of all types of riveted joints.

Information Wanted.

Mail matter addressed to the following members of the International Master Boiler Makers' Association has been returned to the secretary. Will anyone knowing the present address of any of these gentlemen kindly communicate with Mr. Harry D. Vought, 62 Liberty street, New York.

W. H. Jenkins, Albion Iron Works, Ltd., Victoria Can.
James Smith, Union Iron Works, San Francisco, Cal.
M. L. Tooling, Union Iron Works, San Francisco, Cal.
James O'Donnell, Union Iron Works, San Francisco, Cal.
George Lasker, Stationary & Marine F. B. M., Kansas City, Mo.
Frank Fox, Stationary & Marine F. B. M., Livingston, Mont.
William Schollar, N. A. F. & S. F., Needles, Cal.
T. J. Burns, G. H. & S. A. R. R., El Paso, Tex.
William Shofield, Jr., S. P., El Paso, Tex.
E. H. Holmes, Power & M. Machine Company, Cudahy, Wis.
J. D. Good, 56 Fullerton Avenue, Chicago, Ill.
H. Fischer, Dickson Mfg. Co., Scranton, Pa.
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E. Kimmer, M. P. R. R., St. Louis, Mo.
John McIntyre, R. R. B. F., M. C. R. R., Jackson Jct., Ia.
A. W. Ritchie, Potson Iron Company, Toronto, Ont., Can.
P. H. O'Donnell, 248 4th Avenue, Pittsburg, Pa.
G. E. Parker, R. R. B. F., C. & A. R. R., Slater, Mo.
George Thomas, B. F., Southern Pacific, Kern City, Cal.
C. L. Long, C. H. & D. R. R., Cincinnati, Ohio.
Jos. Shirley, McDonald Eng. Co., Ft. Williams, Can.
D. J. Grace, F. B. M., C. R. I. & P. R. R., Horton, Pa.
Elish B. Fisher, 64 Grand Avenue, Chicago, Ill.
G. W. Beauer, T. R. & C. R. R., Toledo, Ohio.
Lee B. Carr, A. F. B. M., Erie Railroad, 533 State Street, Meadville, Pa.
W. M. Loney, C. P. & H. L. Ry., Jacksonville, Fla.
C. H. Watker, Montreal L. & M. Company, Montreal, Can.
Charles Wheelan, R. R. B. B., B. & A. R. R. Shops, Springfield, Mass.
H. Keller, Q. & C. R. R., Chattanooga, Tenn.
Charles Kline, Springfield B. & Mfg. Co., Springfield, Ill.
John K. Bourn, 512 Western Reserve Building, Cleveland, Ohio.
W. Padge, L. & N. R. R., New Decatur, Ala.
J. C. Bellis, R. R. B. F., Southern Railway, Washington, D. C.
J. Zobresky, R. R. B. F., Great Northern, St. Paul, Minn.
E. W. Briston, Quintard Iron Works, New York City.
John J. Smith, F. B. M., C. P. R. R., Box 296 Riverstake, D. C.
F. J. Sullivan, I. C. R. R., Freeport, Pa.
William Cour, F. B. M., O. M. R. R., Mobile, Ariz.
James Toomey, B. F., M. E. C. R. R., Waterville, Mo.
William Wunder, R. R. F. B., Great Northern, St. Paul, Minn.
Henry Webker, 2638 Tulane Avenue, New Orleans, La.
Charles A. Klein, F. B. M., Odlum-Taylor Company, 709 New Raleigh Road, Memphis, Tenn.
Timothy Ahern, N. C. R. R., Paterville, Mo.
J. Barron, 548 East Columbia Street, Alliance, Ohio.
William Snyder, R. R. B. F., R. Railroad, Wilmington, Del.
J. T. Bond, Clarksburg B. Works, Clarksburg, W. Va.
T. C. Tessem, 308 East Grand Avenue, Springfield, Ill.
R. J. Kelly, 310½ Smith Building, Pittsburg, Pa.
C. L. Wells, R. R. B. F., T. & P. R. R., Marshall, Tex.
S. S. Graham, Graham Boiler Works, East Grand Forks, N. D.

PERSONAL.

C. E. LESTER, formerly assistant foreman boiler maker with the Erie Railroad, has been promoted to general foreman boiler maker of all Erie lines west of Salamanca, with headquarters at Meadville, Pa.

E. MCKENZIE is located in New Haven, Conn., where he holds the position of round-house foreman boiler maker for the New York, New Haven & Hartford Railroad.

R. F. Allen, for five years layer-out on the Southern Pacific Railway, has taken a position as foreman of the Pacific Coast Boiler Works in San Francisco, Cal.

CHARLES M. REESE, late of the American Locomotive Company's works at Richmond, Va., will shortly assume the position of general superintendent of the W. J. Oliver Manufacturing Company, Knoxville, Tenn.

W. A. CORNELIUS has been made general manager of the national department of the National Tube Company at McKeesport, Pa., succeeding George C. Crawford, recently appointed president of the Tennessee Coal, Iron & Railroad Company.

GEORGE A. GALLINGER, formerly a traveling representative from the Chicago office of the Independent Pneumatic Tool Company, has been appointed manager of the Pittsburg office of this company, at 1210 Farmers' Bank building, Pittsburg, Pa.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Should the seams of a steam boiler be calked both inside and outside? If calked on only one side, which should it be? L. A.

A.—It is not necessary to calk the seams of a boiler or a pressure tank both inside and outside, although it makes a very good job to do so. If only one side is calked, it should always be the outside. The outside is not only easier to get at in order to do the work, but if only the inside were calked and a leak started, the water would run along between the plates and the exact location of the leak could not easily be found and recalked. Whereas, if the outside is calked, any point at which a leak occurs can be readily seen and the leak at once stopped. Calking both the outside and inside has the advantage that water cannot get between the plates and work out around the rivets, and therefore it will not be necessary to calk the rivets as thoroughly.

Q.—What is the allowable working pressure on a boiler flue 25 inches in diameter and 42 inches long made of ⅜-inch plate? S. A. M.

A.—The British Board of Trade rules provide that circular furnaces with longitudinal joints welded or made with single-butt straps double riveted, or double-butt straps single riveted shall be allowed a working pressure equal to

$$\frac{90{,}000 \times \text{the square of the thickness of the plate in inches}}{(\text{length in feet} + 1) \times \text{diameter in inches}}$$

provided this does not exceed that found by the following formula:

$$\frac{9{,}000 \times \text{thickness in inches}}{\text{diameter in inches}}$$

Substituting the figures given in the inquiry

$$\frac{90{,}000 \times .375^2}{(3.5 + 1)\ 25} = 112.5 \text{ pounds per square inch.}$$

The second formula gives

$$\frac{9{,}000 \times .375}{25} = 135.$$

Therefore since the value 112.5 pounds given by the first formula does not exceed that found by the second formula (135), 112½ pounds per square inch may be taken as the allowable working pressure on the flue.

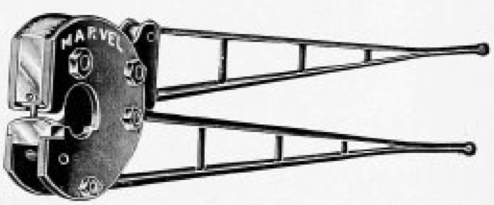
The second formula limits the crushing stress on the material to 4,500 pounds per square inch. If the longitudinal joints, instead of being butted, are lap jointed in the ordinary way and double riveted, then 75,000 should be used instead of 90,000, but where the lap is beveled and so made as to give the flues the form of a true circle, then 80,000 may be used.

When the material or workmanship is not of the best quality, the constants given above should be reduced—that is to say, the 90,000 may become 80,000, the 80,000 may become 70,000, and the 70,000 may become 60,000. When the material and workmanship are not of the best quality, such constants may be required to be further reduced according to the circumstances and judgment of the surveyor. Some of the conditions of best workmanship are that the rivets shall always be drilled after the bending is done and when the plates are in place, and the plates afterward taken apart, the burr on the holes taken off and the holes slightly countersunk from the outside.

ENGINEERING SPECIALTIES.

A Portable Lever Punch.

The illustration shows a portable hand lever punch, to be used for punching sheets, angle-bars, etc. It has a capacity of a ¼-inch hole in ¼-inch stock. The total weight is only 16 pounds, and it has a gap of 2 inches. A hole may be punched



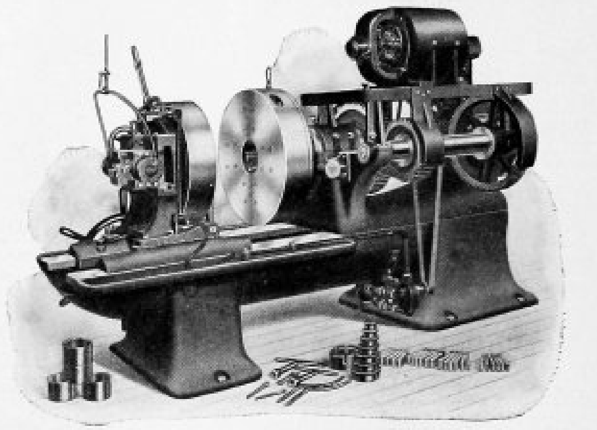
within ⅜ inch of the heel of an angle-bar. The handles, which are of a truss pattern, are of half-round steel. The punch may be clamped to a bench or held in any common vise jaws if it is desired to use it as a stationary punch. The manufacturers are Armstrong-Blum Manufacturing Company, 104 North Francisco avenue, Chicago, Ill.

A New Crane Pipe Machine.

This machine is one of the latest models, and embodies the most modern improvements in the manufacture of pipe cutting and threading machines. It is very substantially and compactly built, consisting practically of but three pieces. All working parts are so placed that strains come directly on top of the base. The motor is located on top of the machine, directly over the bed, where it can be best taken care of, be out of the operator's way and protected from chips. Of the quick-grip and sliding die head type, the machine was designed for use where rapid production is essential.

The gripping chuck is of a specially constructed type, so designed that any pipe may be either gripped or released by moving a lever, without stopping the machine. It contains four jaws made of high grade steel, with eight removable roller contact teeth, which will grip (without slipping) pipe that is not perfectly round. These jaws are adjusted by an internal cam operated by a worm and gear. The rear end of the spindle contains an independent three-jaw chuck, used for centering or gripping long lengths of pipe. To facilitate the operation, removable bushings are supplied to fit in the spindle to guide pipe through the gripping chuck.

The die head is movable, and carries with it adjustable expanding dies in sets of six, pipe-centering guides, and patented air cutting-off attachment, operated by an air pressure device controlled by an air cock. The opening and closing of this cock governs the working of the two cutting-off tools. This is said to be the most efficient and satisfactory means yet invented for cutting off pipe. The dies are of high-speed steel, made extra long, and will cut threads for



extra heavy flanges of fittings, and still maintain the exact taper on the threads. For threading pipe below 4-inch an extension die head is supplied, which should always be used, as it supports the dies and prevents them from bending. The dies may be removed from the head by taking off the cover, which immediately exposes all the dies.

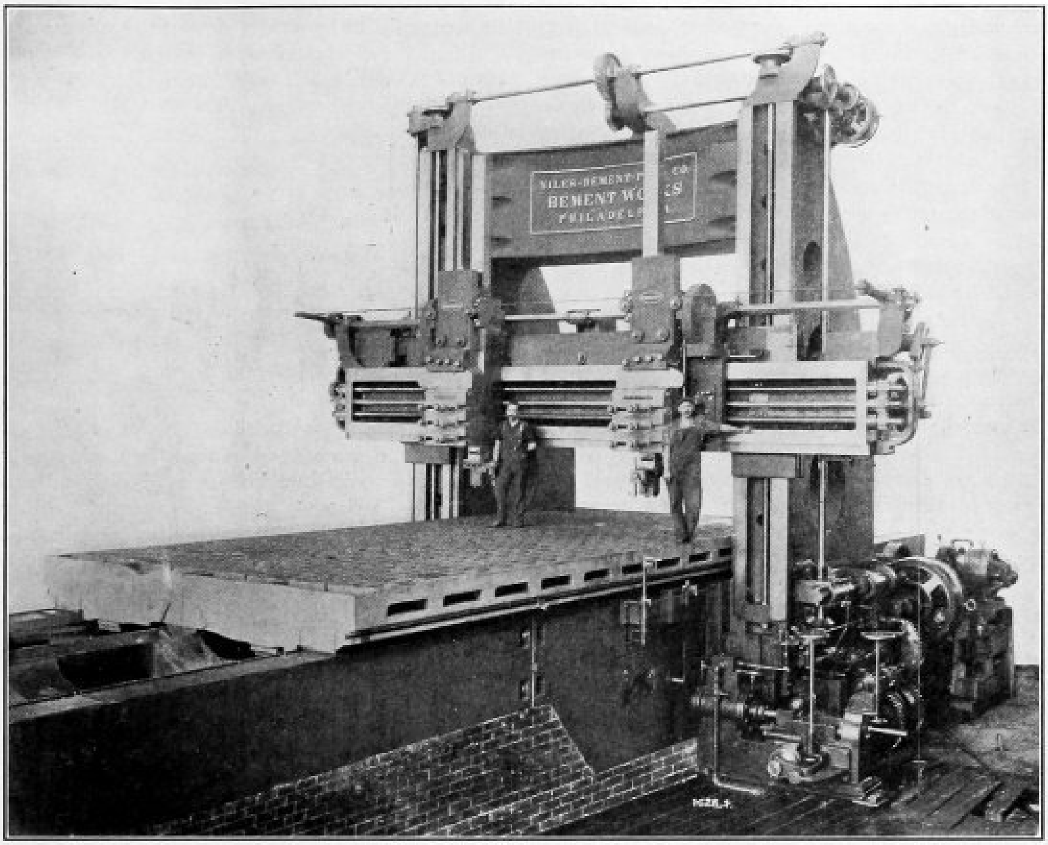
A rotary oil pump is supplied, and particular attention has been given to the distribution of oil on the dies. The belted machine contains a three-step cone pulley, which, with back gears, gives sufficient change of speed for all sizes of pipe within the range of the machine. These machines are furnished for engine, belt or motor drive, the capacity being pipe from 2½ to 6 inches.

Dimensions: Countershaft pulley, 20 inches diameter by 6-inch face; countershaft speed, 125 revolutions per minute; weight, 9,000 pounds; floor space, 9 feet 6 inches by 4 feet 6 inches.

A Gigantic Planer.

Probably the largest and heaviest metal working planer ever built has recently been shipped from the Bement-Niles works (Philadelphia) of the Niles-Bement-Pond Company. The total weight of the machine is 845,000 pounds, or 422½ short tons. Four motors with a total capacity of 207½ horsepower are required to operate this remarkable tool.

The machine is, in general effect, an extremely large planer, but in addition to the movements found on a standard machine, many new ones have been added. Each head is fitted with a slotter bar, independently driven by rack, giving a cutting speed that is practically constant from one end of the stroke to the other, and a quick return. Through motor and change gears the cutting and return speeds can be changed as desired. Each head is arranged for transverse planing, having a planing movement across the bed which can be varied within desired limits, and having a quick return. The movements for slotting and transverse planing make it necessary to throw out the regular driving mechanism to the table and connect it to a separate feed motion, which, in this case, is entirely distinct from the regular feed motion. This throwing out of the driving mechanism, however, means simply that the

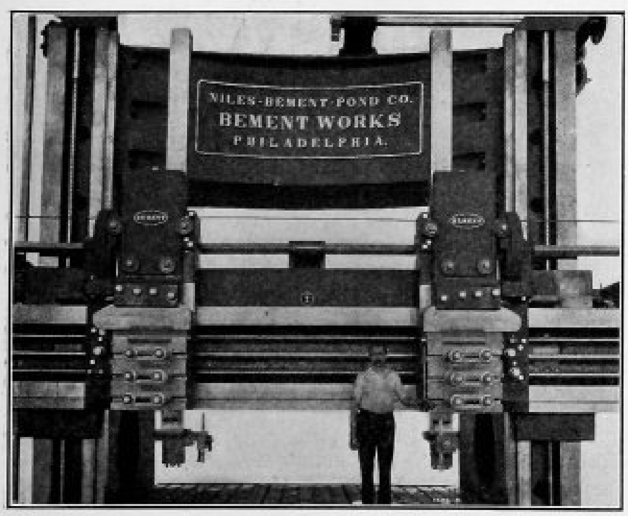


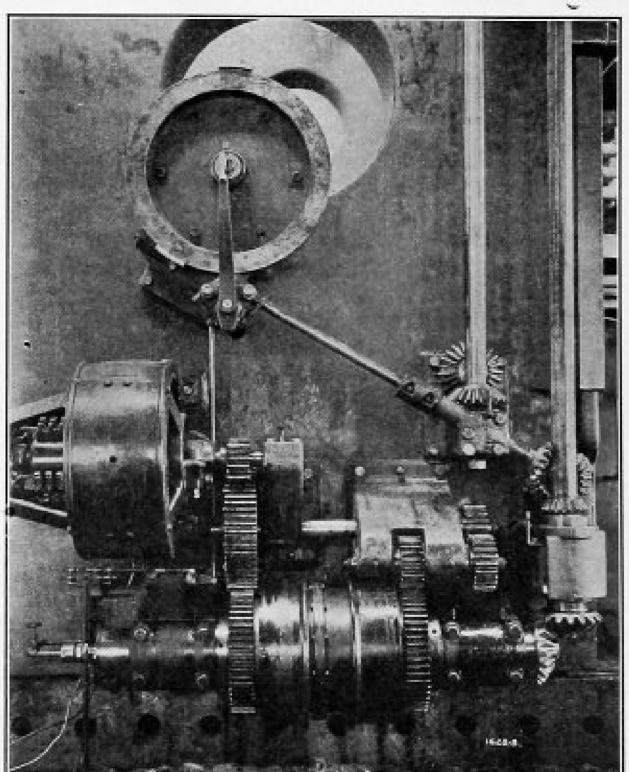
pneumatic driving clutches are thrown into and left in their idle position.

The machine is fitted with its own air compressor and motor, thus making it independent of the air supply in the shop, to which, however, it can be connected if it seems desirable. A complete switchboard is furnished for control of all the motors.

The distance between uprights is 14 feet 4 inches; the maximum distance from table to bottom of cross slide is 12 feet 2 inches; maximum stroke of table is 30 feet; maximum stroke of slotter bar is 8 feet; total width of bed 13 feet; length of bed 60 feet; table ways 15 inches each in width; tool slides 7 feet 8 inches, with 4 feet vertical traverse; cross rail is long enough to admit full traverse of either head between the posts; face of uprights 2 feet 6 inches; vertical height of cross slide, including the top rib bracing, is 5 feet.

The main driving motor is 100 horsepower; slotting and cross-planing motor is 50 horsepower; lifting motor to cross slide 20 horsepower; traverse motor for heads on cross slide 7½ horsepower; air compressor motor 30 horsepower. The cutting and return speeds are variable through the motor, which has a 1 to 1¼ variation and further range by change gears. The cutting speeds are 14 to 25 feet and return speeds





52½ to 65½ feet per minute. The same style of drive is used for the slotter, and gives a cutting speed of 18½ to 30 feet, and return speed of 57 to 71 feet. Cutting speed for cross planing is 11½ to 19 feet, and return speed 35 to 43½ feet. The cross traverse speed to the heads is 50 inches per minute; the vertical speed for raising and lowering cross slide is 26 inches per minute.

The main drive from the 100-horsepower motor is through the gearing to the pneumatic reversing clutches at the base of the upright. The speed of these clutches can be varied to some extent by changing the speed of the motor, and a great variation obtained by the simple reversal of two change gears. The pneumatic clutches are of the N-B-P type, with a large number of friction disks, whereby great friction area is obtained in a comparatively small compass. These clutches, as their name implies, are operated by compressed air. A small valve, easily moved by hand, controls the stopping, starting and reversal of table, and handles satisfactorily the power given out by the large driving motor. In the handling of this amount of power in a motor-driven planer, it is unnecessary to state that it would be quite impracticable if a belt-drive were employed. From this point on to the rack the drive is, in practically every respect, that which is found on any planer, except that in this instance it is exceptionally heavy and powerful.

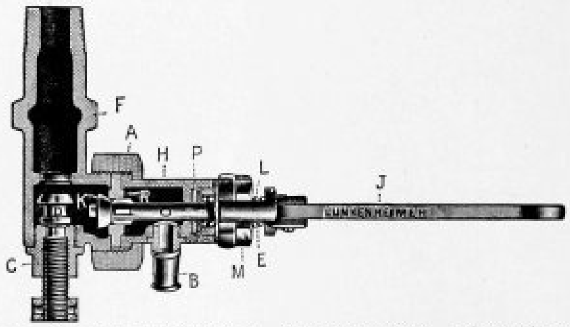
Among the many other new features, not the least is the pneumatic feed for the cross heads. On the side of the upright, just above the gearing, is a cylinder with piston rod extending to the left. This rod carries a rack which meshes into a gear near the bottom of the vertical feed shaft. This shaft has, on its lower end, a bevel gear meshing into another bevel gear on a horizontal shaft, which transmits motion to the vertical feed shaft on the left-hand upright. The movement of these feed shafts is constant at all times, and variation in amount and direction of head feeds is obtained by adjusting the connecting rod in the slotted cranks on the ends of the cross-slide. These cranks are graduated in such a way that definite cross and vertical feeds can be obtained, and by using at the same time the cranks on both sides, an angular feed can be given to the tool, which is at times desirable, as the whole heads were not designed to swivel. The valve for controlling the air to the feed cylinder is thrown automatically at each end of the stroke, this movement being taken from either the main driving gear train to the table or the slotting gearing when slotting is being done. To throw out the feed it is simply necessary to close a valve, cutting off the air supply.

Owing to the great weight and large dimensions, it was impracticable, both from the manufacturing and the shipping standpoint, to make the bed or table in one piece. They were, therefore, divided to bring them within reasonable limits. The central section of the bed is divided longitudinally into three parts, and the two end sections into two parts each, or seven parts in all. The total weight of the bed is about 275,000 pounds. The table is made in two sections, divided longitudinally in the center, and weighs about 140,000 pounds.

An Improved Gage Cock.

The gage cock shown herewith is known by the trade name of "Excelsior," and is manufactured by the Lunkenheimer Company, Cincinnati, Ohio. The cock is made in two parts, held together by the union ring *A*. That part to which the lever *J* is attached contains the operating mechanism and parts most liable to wear. The other part of the gage cock is screwed into the water column, and contains an emergency valve, which is easily opened or closed by means of a wrench applied to the nut *D*. The object of this emergency valve is to make it possible to remove the part containing the operating mechanism, while pressure is on. It will, therefore, be seen that, should accident happen to the cock, or should it be found necessary to clean the same while pressure is on, it can readily be accomplished by simply closing the valve *D*.

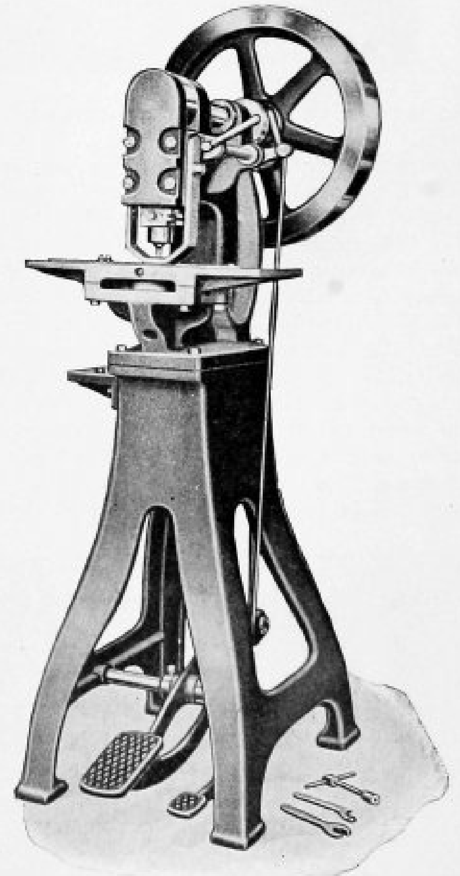
Another important feature in the construction of the gage cock is the renewable, reversible seat *R*, which aids in making



a very durable construction. The lever *J* is adjustable, and can be turned to any desired position. A rope or chain can be attached to it should the same be beyond reach from the floor. The spring *M* will last indefinitely, owing to the fact that there is no possibility of its becoming limed up, or losing its tension. This is due to the fact that it is not in the least exposed to the escaping steam or water.

A Combination Foot Power or Belt Punch.

The illustration shows a small machine which will be found useful for punching light iron. When used intermittently the punch may be operated by foot power and when continuously



by belt power. In either case the fly-wheel is driven and the change from one form of power to the other can be quickly made. The capacity of the machine is such that a ⅞-inch hole can be punched in ⅛-inch stock. The slide or ram is fitted with an adjustable gib to take up any wear which might appear. The total weight of the machine is 500 pounds, the height from the floor to the center of the fly-wheel 50 inches, and the total floor space required 19 by 28½ inches. The stroke of the punch is ¾ inch. This useful machine is manufactured by the Automatic Specialty Company, Sixth and Baymiller streets, Cincinnati, Ohio.

SELECTED BOILER PATENTS.

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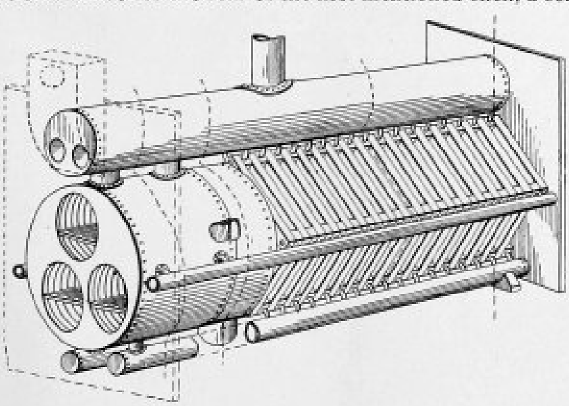
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

870,046. WATER-FEED REGULATOR. Thomas G. Rakestraw, of Detroit, Mich., assignor to U. S. Boiler Supply Company, of Detroit, a corporation of Michigan.

Claim.—In a water feed regulator for boilers, a water column having communication with the boiler, a steam cylinder communication with the water column through a pair of passages, the column being contracted longitudinally intermediate its sides, a piston in the cylinder, float valves ararnged within the column for reciprocation to open and close the passages between the cylinder and column, alternately, to operate said piston, the float valves being arranged upon opposite sides of said longitudinal contraction, and a shut-off valve in the feed pipe to the boiler controlled by the piston. Four claims.

872,456. BOILER. Lloyd Rowan, of Shawneetown, Ill.

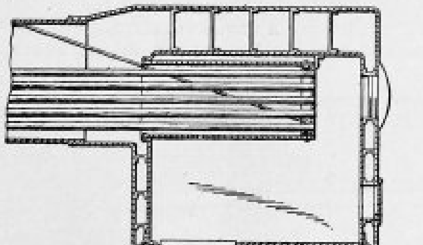
Claim.—A boiler constructed with a cylindrical shell, a series of furnace cylinders in said shell, a shell forming a combustion chamber to the rear of the first mentioned shell, a series



of tube sections arranged at the rear of the combustion chamber, a steam drum extending longitudinally above the shells and tube sections, connection from said shells and tube sections to said steam drum and return flues extending throughout the steam drum, substantially as specified. Four claims.

866,834. STEAM BOILER. Edgar L. Arnold, of Alexandria, Minn.

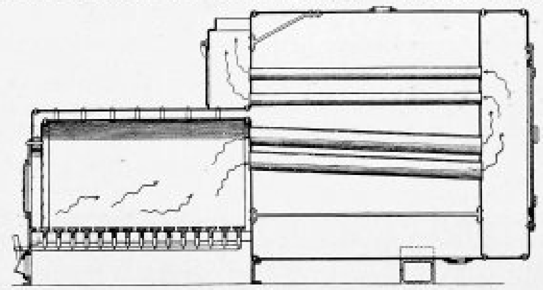
Claim.—In a steam boiler, the combination with a fire box and a grate positioned within the fire box adjacent the front wall thereof, of a hollow cylindrical flue barrel secured at its



forward end in an opening in the front wall of the fire box and extending rearwardly with its rear end terminating slightly short of the rear wall of the fire box, the barrel being closed at its said rear end and being entirely open at its front end, flues extending into the barrel through the open front end thereof, and opening through the rear end thereof, said barrel being spaced completely from the walls of the fire box except at the point of connection of its front end with the front wall of the fire box, the rear end of the flue barrel being located in a plane considerably removed from the vertical plane occupied by the rear end of the grate, and a brace rod extending into the flue barrel through the open front end thereof and secured at its rear end to the closed rear end of the flue barrel adjacent the lower end thereof. One claim.

866,771. BOILER. Alexander B. Burns, of Green Bay, Wis.

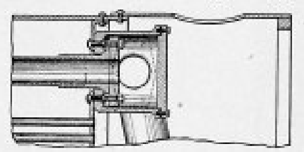
Claim.—In a fire box for boilers, a double-wall jacket, front and bottom openings therein, closure-strips for the openings interposed between the double-walls, in combination with an



ash-pit frame for supporting the fire box at the bottom opening therein, said frame being open at its front, and a door-plate secured to the front of the ash-pit frame and front-walls of the fire box around the opening therein. Two claims.

867,784. T-PIPE. William H. Bellmaine, of Pocatello, Ida., assignor of one-half to George Stone, of Pocatello.

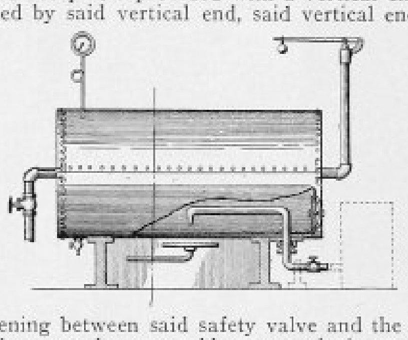
Claim.—The combination with a boiler having a smoke-box, flue sheet and dry steam pipe, of a case fastened to the flue sheet within the smoke-box, a tube passing through the case



and flue sheet and engaging the dry steam pipe, means located within the casing and engaging the end of the tube within the casing for fastening the tube in place, and a steam pipe communicating with the casing and located in the smoke-box. Fourteen claims.

867,631. STEAM GENERATOR. Charles Bakehaus, of Sigourney, Ia.

Claim.—In an apparatus of the class described, the combination with a support, of a cylindrical receptacle carried by said support, said receptacle provided with a vertical end, a safety valve carried by said vertical end, said vertical end provided



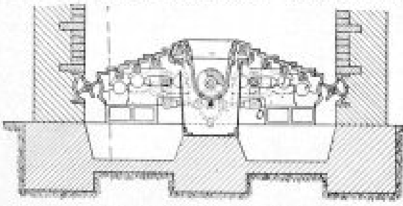
with an opening between said safety valve and the lower portion of said receptacle, removable means closing said opening, a supply pipe extending through the lower portion of said receptacle between said opening and said support, and means engaging said supply pipe outside of said receptacle for securing said receptacle against independent movement upon said support. Six claims.

868,012. FLASH-BOILER. Andrew L. Riker, of Bridgeport, Conn., assignor to Stanley Motor Carriage Co., a corporation of Mass.

Claim.—A boiler comprising a plurality of superposed coils connected in series, successive convolutions of each of said coils rising gradually and continuously from the inlet to the outlet end thereof, the connections between successive coils extending closely adjacent the source of heat. Eight claims.

867,979. STOKER. Charles A. Knowlton, of Erie, Pa., assignor to the American Stoker Co., of Erie, a corporation of New York.

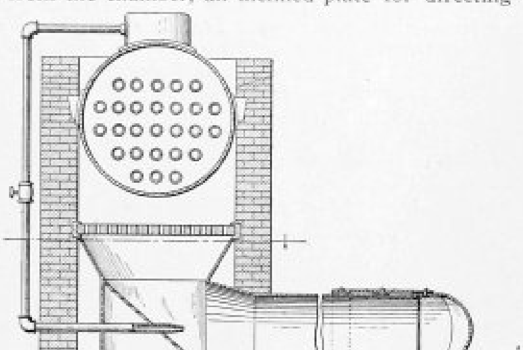
Claim.—In a stoker, the combination of a feed box arranged to deliver fuel from beneath the fire; a fuel support in the form of a twyer cap for said box; a grate arranged at the side of



said twyer cap and adapted to carry fuel from said cap; said grate comprising reciprocating grate bars; a carriage for supporting said reciprocating grate bars; rollers for supporting said carriage; and means for reciprocating said carriage laterally relative to the direction of feed through the feed box. Seven claims.

868,455. STEAM ASH-REMOVER FOR BOILERS. Jonas A. Kretzer, of Mound City, Mo.

Claim.—In an apparatus of the class described, the combination of a firebox including a grate, a collecting chamber below the grate, a hopper between the chamber and grate, a duct leading from the chamber, an inclined plate for directing the



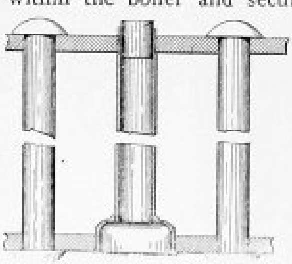
ashes and cinders into the duct, a steam discharging pipe extending through and supported on the inclined plate and arranged in axial alinement with the duct, and a deflecting device at the outer end of the duct. Three claims.

868,832. ROCKING GRATE. George C. Andrews, of Minneapolis, Minn.

Claim.—The combination with a boiler having an approximately cylindrical fire box, of a sectional circumferentially expansible grate supporting ring, legs or spacing projections connecting the sections of said ring to the said boiler, of a plurality of toothed grate bars mounted on and supported by said supporting ring. Two claims.

869,000. SAFETY DEVICE FOR STEAM-BOILERS. Charles Letteri, of Columbus, Ohio.

Claim.—A steam boiler having an opening in its shell between the steam and combustion chambers, a closure for said opening located within the boiler and secured to the shell



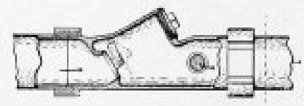
at said opening and to a rigid part of the shell removed from the combustion chamber, said closure adapted to be ruptured when subjected to abnormal heat due to the lowering of the water in the steam chamber. Three claims.

869,158. UPRIGHT STEAM-BOILER. Samuel D. Brear, of Tacoma, Wash.

Claim.—The combination with an upright boiler, of a casing inclosing the same so as to leave a space around and at the top of the boiler, said casing consisting of a cylindrical shell having at its lower end, at one side, a lateral extension from the top of which extends a smoke flue, and brackets secured to the wall of the fire box upon which said casing rests. Two claims.

869,212. FEED-WATER HEATER. Thomas M. Monahan, of Middleport, Ohio, assignor of one-fourth to John B. Lindsey and one-fourth to Curtis B. Smith, of Middleport.

Claim.—In means of pre-heating the feed water for locomotives, the combination of the boiler, a feed water supply-pipe for the same, an injector to force the water through the pipe, a tubular housing open at opposite ends where it connects to



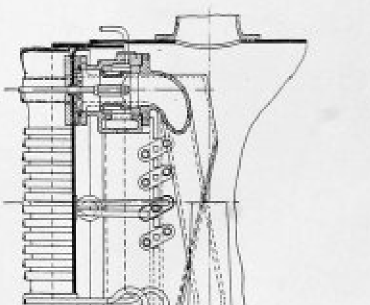
the supply-pipe mentioned of which it forms an inserted part, said housing being provided with a lateral port open towards the side of the boiler and an upwardly extended part where it is also open, a screw-cap fitted to this open part, a check-valve near one end of the housing and below this screw-cap, and a short horizontal pipe connecting the housing at its lateral port with the side of the boiler. One claim.

869,575. FURNACE-DOOR. Carl J. F. Johnson, of Cleveland, Ohio, assignor of one-half to Carl W. Carlson, of Cleveland.

Claim.—A door for furnaces and the like comprising a hollow structure, a vertical partition dividing the same into two longitudinally extending chambers, passages connecting one of said chambers with the opposite outer face of the structure, air supply connections for said last named chamber, and water supply connections for the remaining chamber. Seven claims.

869,600. SUPERHEATER. Max Toltz, of St. Paul, Minn., assignor of one-fourth to Charles Gilbert Hawley, of Chicago, Ill.

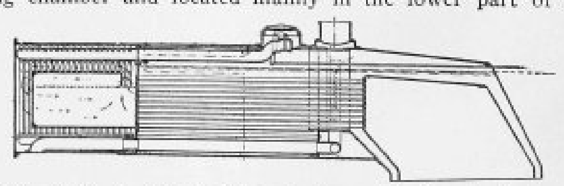
Claim.—A locomotive boiler containing a substantially circular row of enlarged fire flues and provided with a dry-pipe, in combination with a substantially circular saturate steam



header connected to said dry pipe, a substantially circular superheated steam header, a throttle valve provided in the latter, steam feed pipes connected thereto, and a plurality of superheater elements occupying said enlarged flues and having their ends connected to respective headers. Seventeen claims.

869,805. LOCOMOTIVE-BOILER. Sidney A. Reeve, of Worcester, Mass., assignor to Charles F. Brown, trustee, of Reading, Mass.

Claim.—A locomotive type boiler comprising a tubular shell, a vaporizing-chamber therein, a preheating-chamber therein embracing and having a common steam-space with said vaporizing chamber and located mainly in the lower part of the



tubular shell, a gas-chamber in line with the shell located forward of said vaporizing and preheating chambers, and a steam superheater situated in said gas-chamber, and composed of a series of superheating-sections located mainly in the upper part of the gas-chamber out of the line with the fire tubes. Nine claims.

THE BOILER MAKER

VOL. VIII FEBRUARY, 1908 No. 2

BOILER SHOP OF THE THOMAS C. BASSHOR COMPANY.

The boiler shop of the Thomas C. Basshor Company, engineers and contractors, is located at the junction of Bush street and the Baltimore & Ohio Railroad, at Baltimore, Md. The shop is a modern steel structure 250 feet long by 110 feet wide. It is divided into three bays or aisles, the middle one being 50 feet wide, and the two side bays each 30 feet wide. Most of the machine tools are located in a line between the side and center bays, thus leaving the space in the center of the shop entirely free for the erection of heavy work, and a large part of the space in the side bays clear for the erection of light work.

The tracks of the main line of the Baltimore & Ohio Railroad pass by one end of the shop. Two spur tracks lead from the main line, one into the shop itself and the other along one side of the shop, just outside the building. The first of these spur tracks makes it possible to ship the finished product directly from the erecting floor into the cars by means of a large electric overhead traveling crane, which spans the entire width and travels the entire length of the center bay of the shop. The second spur track, which is located just outside of the shop, is used for unloading coal, boiler tubes and bar iron. This material is stored in sheds located, as may be seen from the plan view of the shop, Fig. 4, just outside the building, convenient to the erecting floor.

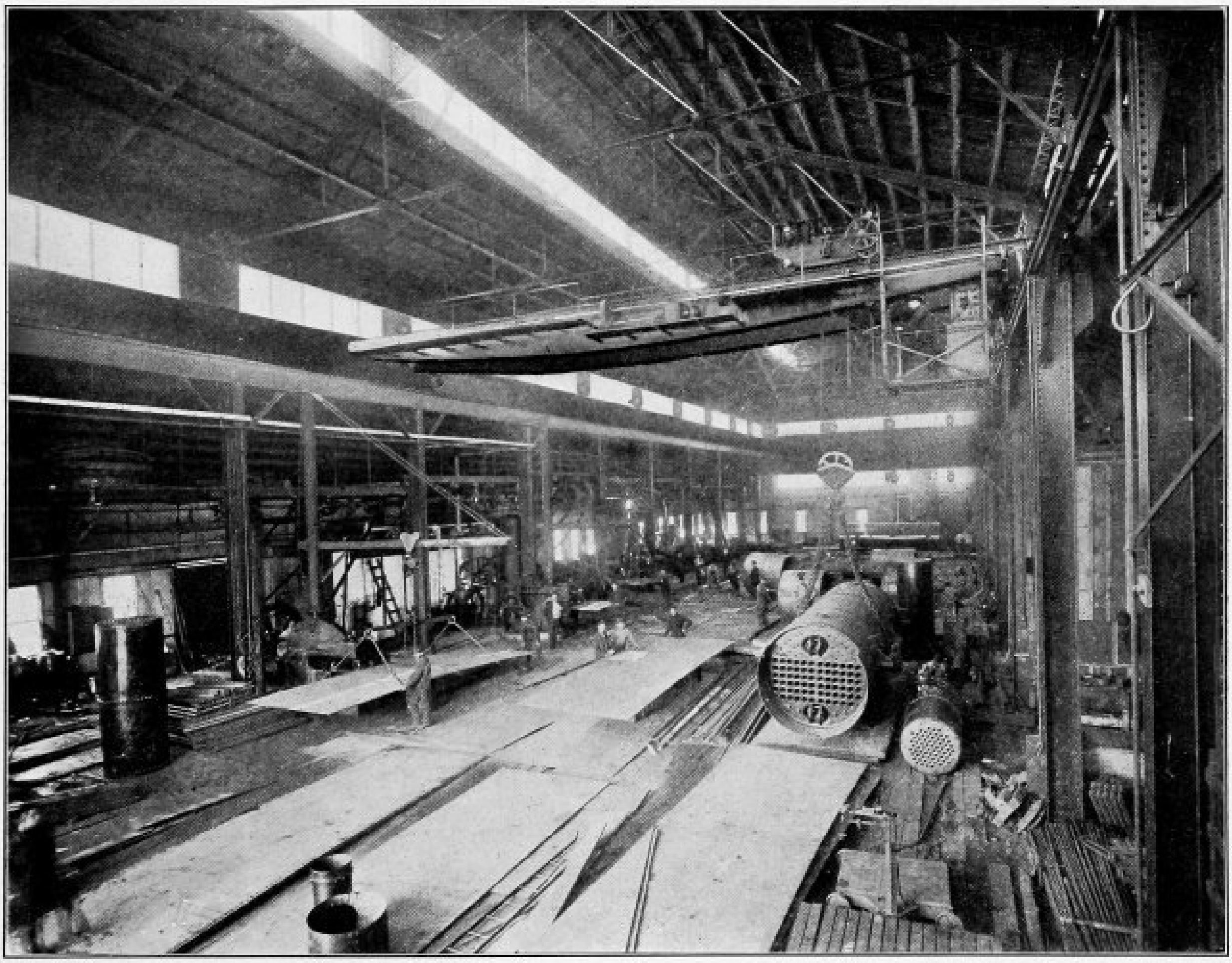


FIG. 1.—VIEW OF THE MIDDLE BAY IN THE BOILER SHOP OF THE THOMAS C. BASSHOR COMPANY.

Ample provision is made for the rapid and economical handling of the work throughout the entire shop. A large boom derrick is located just in front of the shop, by means of which material may be unloaded directly from the main line tracks of the railroad, and either swung into the shop or placed on trucks, which may be drawn into the building on a small narrow-gage shop track. This derrick is operated by means of a pair of Lidgerwood hoisting engines, which are also used for hauling cars in and out of the shop. The location of the derrick and engines, and also the sweep of the derrick is plainly shown in the plan of the shop, Fig. 4. For handling the work inside the shop, the center bay is fitted with a Shaw electric traveling crane of 30 tons capacity, which, as has been stated, spans the entire width and travels the entire length of this part of the shop. The light material in the side bays is handled by means of overhead trolleys, equipped with Yale & Towne triplex and Harrington improved chain blocks. In addition to this, each of the machine tools is provided with an individual jib crane for handling the work.

there are two high-speed punches of the Cockburn-Barrow Machine Company's make, one with a 15-inch gap and the other with a 50-inch gap. Beyond these machines are a 36-inch combination punch and shear, a punch and angle-iron shear and a horizontal punch, all manufactured by the Cleveland Punch & Shear Company. On the same side of the shop are also a pair of 5-foot bending rolls, an angle-iron bending machine and a Lenox rotary bevel shear. Three power drill presses are installed for drilling tube holes, etc. At the extreme end of the shop is located the flanging fire, bending plate and other appliances for performing the necessary blacksmith work. On the opposite side of the shop is a 100-ton 10-foot gap hydraulic riveter, manufactured by R. D. Wood & Co. Water is supplied for the riveter under a pressure of 2,000 pounds per square inch by a duplex steam pump 16 by 2⅞

FIG. 2.—EXTERIOR VIEW OF BASSHOR BOILER SHOP, SHOWING THE LARGE BOOM DERRICK FOR UNLOADING MATERIAL.

Power for the shop is supplied by a 220-volt Crocker-Wheeler electric generator, driven by a 100-H. P. automatic Skinner engine, the engine and generator being direct connected. Steam is furnished by one 150-H. P., horizontal return tubular boiler of the company's own make. The boiler is 18 feet long by 72 inches in diameter and contains seventy 4-inch tubes. The working pressure is 125 pounds per square inch. At present the power is distributed through the shop partly by line shafting and partly by individual motors for each machine. It is the intention of the company finally to have each machine driven by an electric motor, and this change is being gradually made. Besides the boiler, engine and generator, the engine room contains one 500 cubic foot, two-stage American air compressor for supplying the shop with compressed air for the operation of the various pneumatic tools.

Fig. 4 shows in detail the arrangement of the shop and location of the machinery. The material, which is received at the end of the shop nearest the railroad tracks, is laid out at this end of the shop and then passed on to the machines to be punched, sheared and bent to shape. At this end of the shop

by 12 inches, installed with an accumulator 6 feet 6 inches in diameter by 10 feet high. The work is held at the riveter by the usual form of hydraulic lift. In the center of the shop, on the same side as the hydraulic riveting apparatus, is a completely equipped tool room. Here all the necessary machine tools are installed for making and repairing tools.

Besides the tools already mentioned the shop has a complete equipment of all the latest improved pneumatic tools, including drills, chipping and riveting hammers, holder-ons, etc. An 84-inch gap Allen pneumatic portable riveter is also in use.

All of the work turned out by this company, which consists of practically everything in the sheet metal and boiler line, has a special character, no work being carried in stock. Boilers of all descriptions are built to specifications. The view given of the erecting floor shows a number of corrugated furnace boilers, aggregating a total horsepower of 1,700, which are now under construction by this company, and also some special plate work in the form of a water tank and tower. This photograph shows that the product of the company is shipped to all parts of the country.

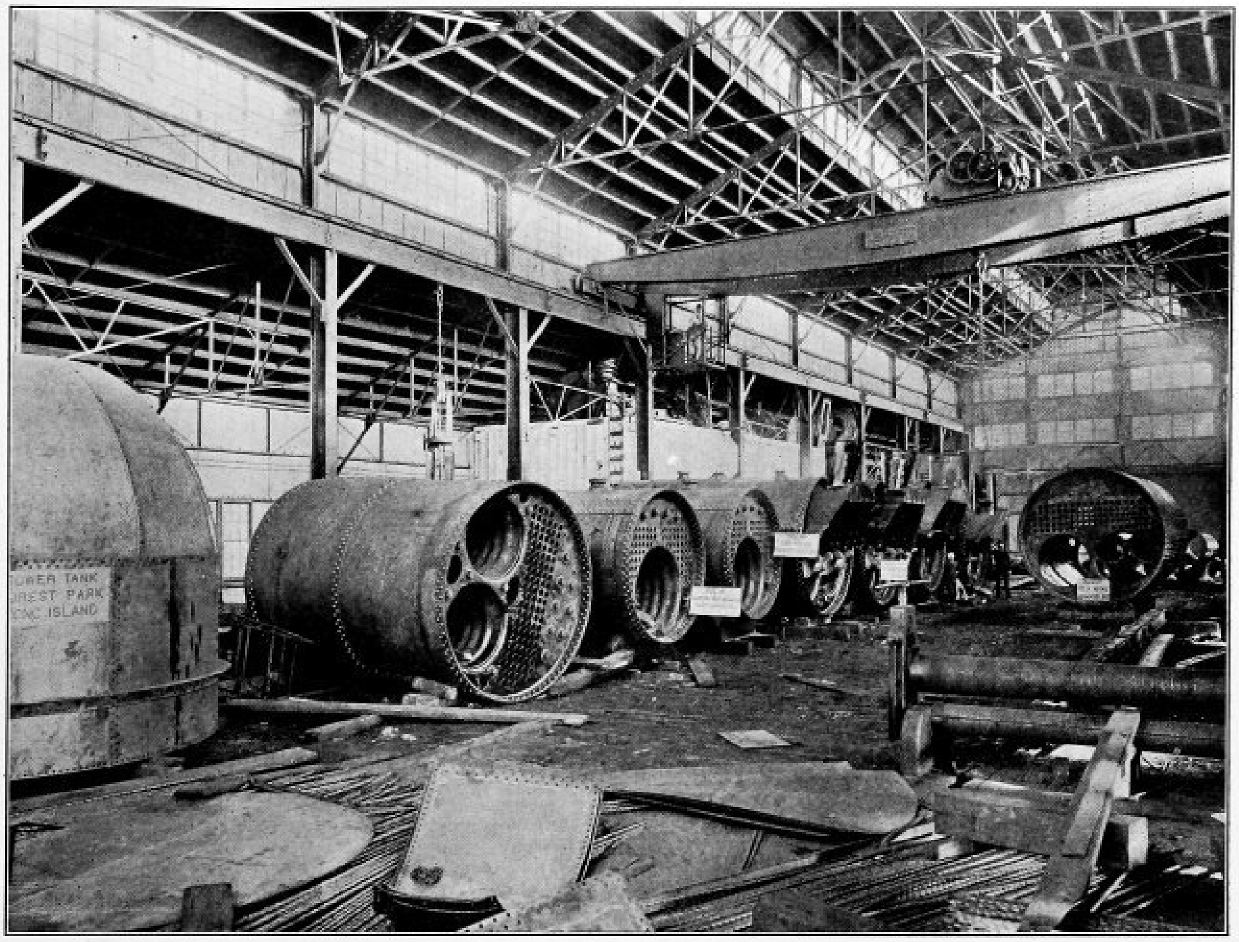


FIG. 3.—VIEW ON THE ERECTING FLOOR OF THE THOMAS C. BASSHOR COMPANY'S SHOP.

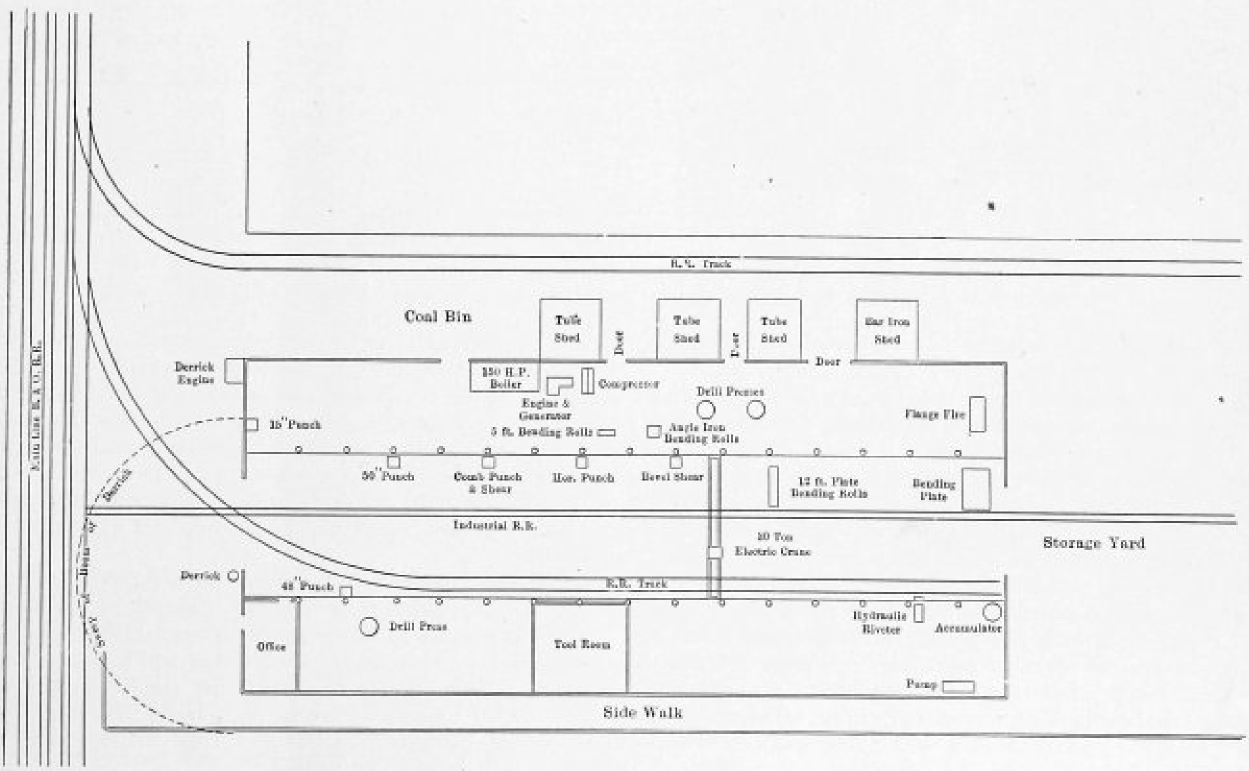


FIG. 4.—PLAN OF THE THOMAS C. BASSHOR SHOP, SHOWING LOCATION OF MACHINERY AND OTHER EQUIPMENT.

Boilers of the Hamburg-American Steamer Kronprinzessin Cecilie.

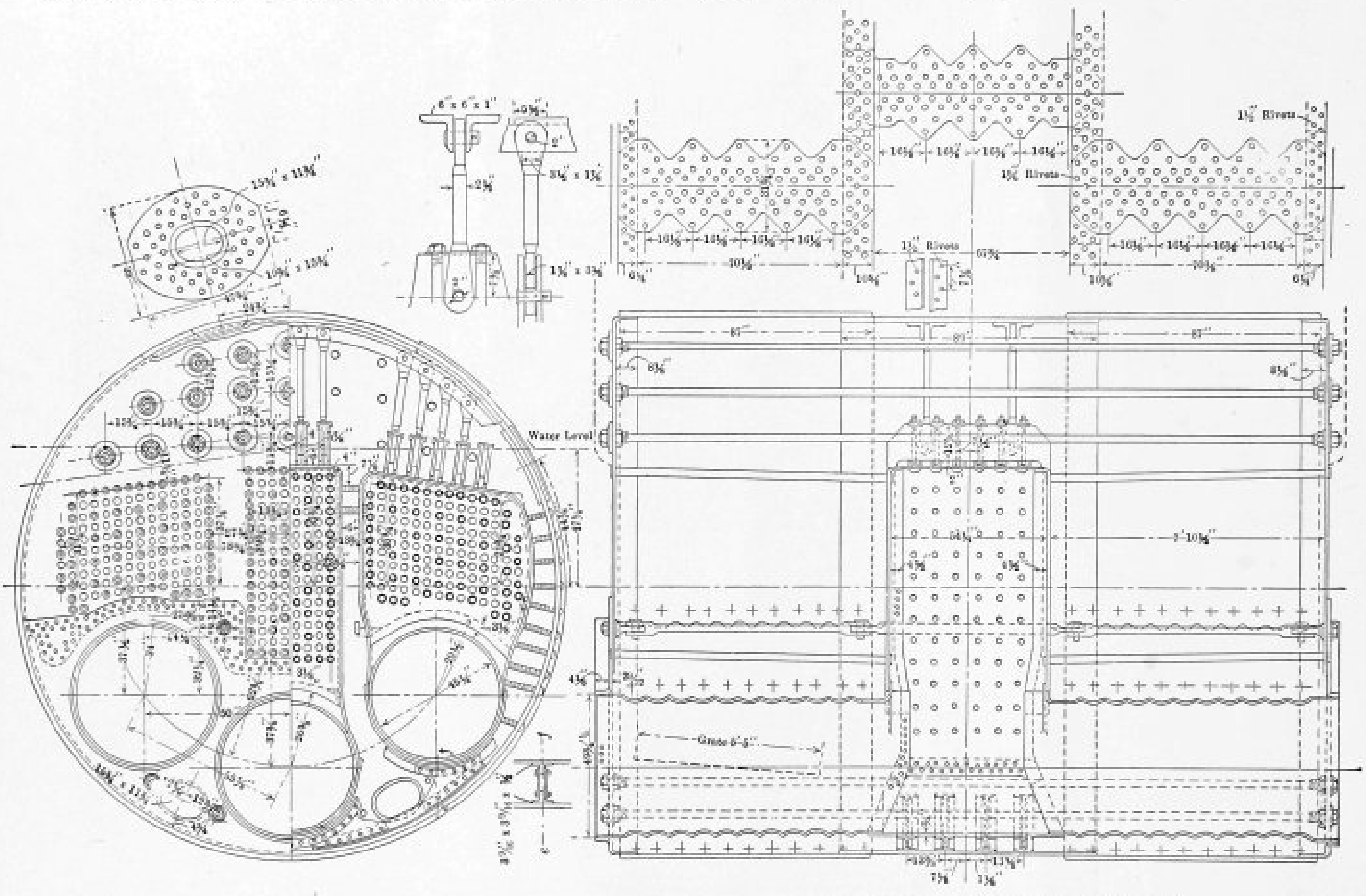
The *Kronprinzessin Cecilie* was built by the Fredrich Krupp Aktiengesellschaft Germaniawerft, Kiel, Germany, for the Hamburg-American Line for service between Hamburg and South American ports. She is a vessel of 14,350 tons displacement, with a length of 470 feet, a beam of 55 feet and a mean draft of 25 feet. Accommodation is provided for 235 first-class, 40 second-class and 914 third-class passengers, which, together with a crew of 200 men, make a total of 1,389 persons on board when all accommodations are taken.

Two main engines of the four-cylinder, vertical, inverted, direct-acting, quadruple expansion type, each capable of developing about 3,035 H. P. at 79 revolutions per minute and a steam pressure of 214 pounds per square inch, drive the ship at a speed of about 15 knots.

Three double and one single-ended boilers of the cylindrical type, working at a pressure of 214 pounds per square inch, are located in one boiler room, and have a single funnel. There are three furnaces at each end of the double-ended boilers, and at the front of the single-ended one, making a total of twenty-one fires. The furnaces have internal and maximum diameters of 3 feet 9¼ inches and 4 feet 1¼ inches. The thickness is ¾ inch. The grates are 5 feet 5 inches in length, the grate surface for each double-ended boiler being 128.1 square feet, while the heating surface in each of these boilers figures out at 5,382 square feet, or a ratio of 42 to 1. The grate surface of the single-ended boiler is 64.6 square feet, and the heating surface 2,152 square feet, which makes an aggregate grate surface of 448.9 square feet, and a total heating surface of 18,298 square feet, or 40.7 to 1 of grate.

The double-ended boilers have a length over the ends of 20 feet 5½ inches and are made in three courses, two being outside and one inside. The outside diameter is 15 feet 10 inches, while the thickness of the plates is 1.6 inches. Each boiler contains three Morison suspension furnaces in each end, with a separate combustion chamber for each pair of furnaces opposite each other. The length of tubes between tube sheets is 7 feet 10½ inches, and they are spaced 4 inches apart in each direction. Each end of each double-ended boiler contains 414 tubes, of which 184 are stay-tubes and 230 are ordinary tubes. All have an outside diameter of 2¾ inches, with a thickness of 0.315 inch for the stay-tubes, and 0.1575 inch for the others. The front tube sheets have a thickness of 1.06 inches, while the back tube sheets are 1.02 inches thick.

The tops of the combustion chambers, ⅝ inch thick, are supported by the usual bridge girder, there being four on the central chamber and five on each of the side chambers. Each carries six supporting bolts. Each of these girders, with the exception of the one in each case nearest the shell in the side combustion chambers, is supported in turn by two sling stays 2½ inches in diameter, and carried each on a continuous pair of double angles 6 by 6 by 1 inches, riveted to the shell. The spacing of the screw stay-bolts in the combustion chambers is 7½ inches in each direction. These bolts are 1¾ inches in diameter.



SECTIONS THROUGH ONE OF THE DOUBLE-ENDED BOILERS, WITH DETAILS OF RIVETING, MANHOLES AND SLING STAYS.

Above the combustion chambers are twenty-one through stays, of which fourteen have each a diameter of 2⅞ inches and are provided with washers 10⅝ inches in diameter, while the others have a diameter of 2½ inches and have 10¼-inch washers. In the lower part of the boiler are six stays of the latter size, of which four are through stays, while the other two, passing between the combustion chambers, are made up of three sections swiveled together.

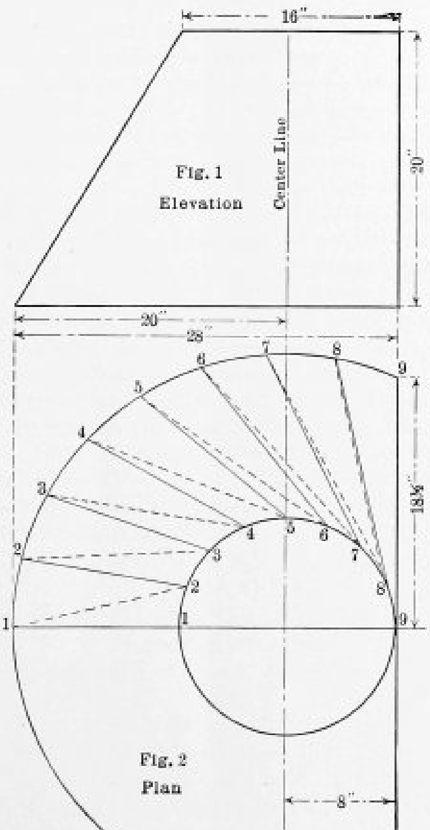
Each course of the boiler is made of a single plate, with a butt joint and double butt straps, the latter having a thickness of 1¼ inches. The strength of the outer courses in the boiler shell has been computed as 90 percent of the uncut sheet, and the inner course is given as 88.15 percent, with a thickness a trifle greater than the outer. The riveting has been done so completely as to furnish a rivet strength in excess of that of the unbroken shell by about 25 percent. The shell steel has been subjected to tests which show a tensile strength of 66,850 pounds per square inch, with an extension of 20 percent in 8 inches. The remaining plates show a strength of about 60,000 pounds per square inch, with an extension of 25 percent. The rivet material shows a strength of 62,500 pounds per square inch, with an extension of 20 percent. The plates are of Siemens-Martin mild steel, and the riveting, wherever possible, was done by hydraulic process.

The funnel, which has a circular section, consists of an inner and an outer tube, with sufficient air space between them, the diameters being 10 feet 2⅛ inches and 12 feet 9¾ inches, respectively. Howden's forced draft is used, and two ventilators of 2 feet 11½ inches in diameter are provided for each fire side in the boiler room.

Layout of a Taper Course with a Flat Side.

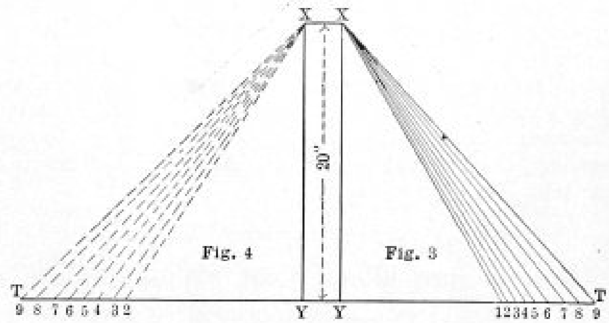
BY H. S. JEFFERY.

In order to lay out the pattern as shown in Fig. 5, the respective side and end views must be drawn up. Fig. 1 represents the side view of the taper course as it will appear



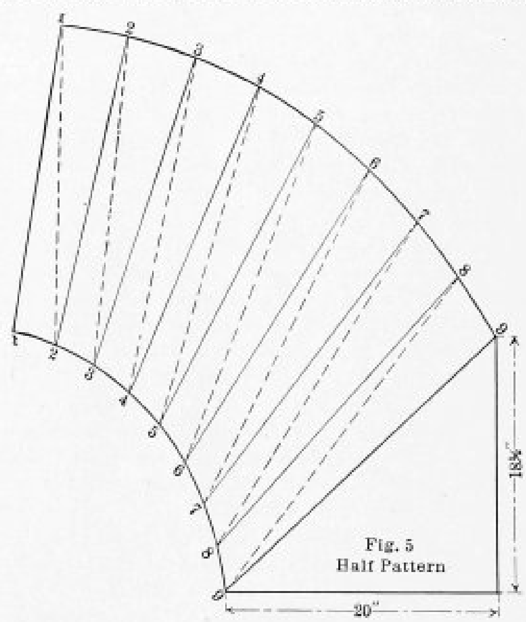
when rolled up into its true shape or position. Fig. 2 represents the relation of the respective ends. The dimensions given in Figs. 1 and 2 show the small diameter to be 16 inches, the length of the course to be 20 inches, and the large end to be drawn with a 20-inch radius with the flat side extending 8 inches beyond the center line.

Having drawn up the outline of Figs. 1 and 2, divide the semi-circle of the small end into any number of equal spaces; in this problem eight equal spaces have been taken. Now divide the curved surface of the large end into the same number of equal spaces as the small end. Number the spaces from 1 to 9, inclusive, and connect together the



spaces as shown. The writer's practice is to connect the spaces together with dotted and solid lines, as this permits the layer-out to keep the layout from getting confused, as will be the case when the lengths of the various lines are nearly equal. It is well to connect together figures of equal value with solid lines, and figures of unequal values with dotted lines.

The value of this method will be more fully brought out in Figs. 3 and 4. It is not really necessary to draw up the side elevation, Fig. 1, as about all the information required is the



length, 20 inches. Fig. 2 is practically the whole foundation of the problem.

After connecting the lines as shown in Fig. 2, turn to Figs. 3 and 4. Draw the vertical lines *Y-X* in Figs. 3 and 4, 20 inches long, which is equal to the height of the course, as shown in Fig. 1. Now draw the horizontal lines *Y-T*, Figs. 3 and 4, at right angles to the vertical lines *X-Y*. Step off from Fig. 2, on the horizontal line of Fig. 4, the length of the dotted lines. Likewise take the length of the solid lines of Fig. 2 and step them off on the horizontal line of Fig. 3. Draw the connecting solid and dotted lines to the apex *X*. These slant lines just drawn give the true length of the lines for the pattern, Fig. 5.

In order to lay out the work rapidly, as well as to avoid error, it is well to use two pairs of dividers; setting one pair equal to the spaces of the large end and the other pair to the spaces of the small end. Draw the vertical line, Fig. 5, from 1 to 1, equal to the full line 1 from the base to point *X*, Fig. 3. Step off one large space at the top and one small space at the bottom.

Take the length of the dotted line 2 from the base to the point *X*, Fig. 4; using 1 as a center, Fig. 5, draw an arc cutting the arc previously drawn at the bottom. Then take the length of the solid line 2, Fig. 3; using 2 as a center, Fig. 5, draw an arc cutting the arc previously drawn at the top. The balance of the layout is carried out in a like manner, exercising care not to use the wrong line. It will be understood that the plate is worked from the neutral diameter of the taper course. The wedge-shaped piece is merely 18½ inches at the bottom, tapering off to nothing at the top. Assuming that this is a butt joint, the pattern is complete.

How to Burn Illinois Coal Without Smoke.

BY L. P. BRECKENRIDGE.

SMOKE PREVENTION WITH THE HORIZONTAL FIRE-TUBE BOILER.

The horizontal fire-tube boiler is much in use in the smaller units of from 50 to 150 H. P. It was brought into prominence in the early days of American steam boiler practice as the natural successor of the plain cylinder and flue boilers, all of which were externally fired. It soon became the standard type of boiler throughout manufacturing New England, where in many places it still retains its position on account of its cheapness and its economical operation with all grades of anthracite and many grades of bituminous coals, especially those containing a high fixed carbon content.

With this boiler combustion takes place mostly on the grate or at a short distance above it. Many plants have been installed with this type of boiler, in which the grate has been placed not more than 14 to 16 inches beneath the boiler. These plants have burned anthracite coal successfully. With the introduction of the West Virginia bituminous coals containing small amounts of volatile combustible matter, the grates were lowered under this type of boiler to 24 and 30 inches with good effect. Still, with either coal, much the greater part of the heat was generated on or near the grate and the heat made available for transmission was largely radiant heat. The plates directly over the fire itself transmitted a correspondingly large part of the heat of the coal to the water in the boiler. The satisfactory performance of the fire-tube boiler with Eastern coals, together with its availability, made it naturally the boiler to be adopted by manufacturers moving westward with the center of population. It is easily seen, however, that with Illinois coals carrying 30 to 40 percent of volatile combustible matter and burned at rates which produce flame lengths of from 5 to 20 feet, this type of boiler as usually set is by no means adapted for the smokeless consumption of this kind of fuel. There is, in fact, no better method of producing dense black smoke with Illinois coal than to install a horizontal fire-tube boiler with the usual furnace, and hand fire such a plant with run-of-mine coal. In such an outfit all the fundamental principles for smokeless combustion are disregarded. The method of introducing the coal directly into the hot furnace, in fine dust and large lumps, prevents slow or uniform distillation of the gases; the air supply through open doors, through holes in the fire, or through a fuel bed of varying thickness is neither correct in quantity nor is much of it properly heated; the mingling products of combustion come in contact with the cool surface of the plates of the boiler, reducing the temperature of the gases below the ignition temperature before combustion is completed.

Having in view these defects of the usual plan of operating the fire-tube boiler with Illinois coal, many ways suggest themselves by which these faults may be corrected. It is possible to burn Illinois coal without smoke with fire-tube boilers, but the furnace requires special treatment and such settings are not common. The plans usually proposed are either low-set stokers or extended Dutch oven furnaces. When hand-firing is adopted the wing wall furnace or other form of mixing baffles or piers is of great assistance. With any of these devices careful firing is very necessary for satisfactory results. The twin brick arch furnace which keeps the gases away from the boiler plates altogether is an effective smoke preventive. Careful firing with low rates of combustion (12 to 16 pounds) per square foot of grate, assisted by automatically controlled air supply, will often enable these settings to be run so as to escape the fines of city smoke inspectors, but they can hardly be compared as to smokelessness with such settings as are employed with water-tube boilers. Horizontal tubular boilers are often adopted on account of their cheapness, and when such is the case the addition of any special furnace constructions or any special devices to aid in smoke prevention, is seldom given any consideration. From what has been said it is doubtless evident why this type of boiler is so frequently found to be one of our worst smoke offenders.

BURNING ILLINOIS COAL IN LOCOMOTIVE BOILERS.

The writer is compelled to admit that he does not know how to burn Illinois coal in a locomotive boiler under the usual operating conditions without making smoke. Careful firing is the most effective way of reducing the amount of smoke made, but no fireman can be found skillful enough to meet the exigencies which are always arising and to operate a locomotive boiler in service without smoke even 75 percent of the time when using Illinois coal. It is not possible here even to enumerate the many devices which have been tried to prevent smoke production on locomotive boilers. The high rates of combustion on the grate of this boiler, often reaching 150 pounds, and sometimes 200 pounds per square foot of area, produce temperatures which soon destroy all forms of fire-resisting material or other constructions not backed up by water-jacketed metals. Were it not, however, for the many and sudden changes in the conditions of operation imposed by the very duties for which the locomotive is designed, all other obstacles might possibly be overcome and the locomotive become smokeless. Fortunately we can clearly see how to eliminate the smoking locomotive from the thickly populated districts by the use of the electric locomotive which now is able to meet the demands placed upon it for speed, acceleration and tractive effort. It is also pointed out that the large power plant will now produce the electricity needed for this service with greater economy and at the same time burn Illinois coal without smoke.

HOW TO HAND-FIRE ILLINOIS COALS SO AS TO REDUCE THE PRODUCTION OF SMOKE.

There are many small power-plant units that are hand fired which smoke badly. The construction of many of these furnaces is such that it is almost impossible to operate the plant without smoke. Still something might be done to reduce smoke if the fireman exercised more care in firing. Whatever can be done by the fireman in the way of properly introducing the fuel into the furnace is just so much gained and it relieves the auxiliary mixing devices or baffles if such exist from just so much work later on. The best method of hand firing for smokelessness is also the best method for attaining economy. There are three generally recognized methods of hand firing: (a) The spreading, (b) the coking and (c) the alternate. The first is satisfactory and generally used for anthracite; the second for coking coals and the last for non-coking coals. It is the alternate method that is best suited to Illinois coals. This method is described as follows. The fuel bed area is divided into equal parts, two, four, or six, depending on the size of the entire surface. The fresh coal is fired alternately on one-half of these areas at a time at such intervals as may be necessary to hold the steam pressure. Depending on the rate of driving, these intervals will vary from 1 to 5 minutes. For small areas, first one-half the surface of the fuel bed is covered and then perhaps 3 minutes later the other half. This method allows much of the air supply to come through the bright fuel bed and thus become heated and suitable for mixing with the highly volatile content which is being rapidly driven from the freshly fired coal on the other side. Just because fresh fuel has been spread over one part of the fuel bed, the air most needed at that moment cannot as easily flow through it, and another part of the fuel bed should be left free for its passage at that time. When the fuel bed area is very large, some checker-board system of firing may be adopted, which, when alternately fired and left free for air passage, will result in a large reduction in the amount of smoke produced by the too common method of spreading the coal over the entire surface at each firing. It must not be forgotten that a large supply of warm air is needed immediately after fresh fuel is spread over a part or all of the fuel bed; this is best supplied as just explained, but it may be advantageous to provide for still more air by leaving the fire doors open slightly just after each firing. There are several devices on the market which provide for an air supply over the fire, which are turned on with the opening or closing of the fire door and which can be arranged to close at the end of any desired time, depending upon the rate of driving and frequency of firing found desirable. The firing of small amounts of coal at frequent intervals produces less smoke than firing large amounts at longer intervals. The latter method, however, usually proves less tiresome to the fireman and is for that reason more frequently adopted.

THE DISTANCE BETWEEN THE BOILER AND THE GRATES.

Having in mind the horizontal fire-tube boiler, the distance from the bottom of the boiler to the grates should be from 30 to 34 inches. At this distance the flame from Illinois coals will sweep along the bottom of the boiler and much smoke will result. Still it must be borne in mind that a large part of the heat to be obtained from the burning of the fixed carbon part of these coals is transferred to the shell in the form of radiant heat and for this purpose the grate should be near the boiler. While it is necessary in preventing smoke, that the flames be kept from the cooling surfaces of boilers, this cannot be accomplished by simply lowering the grates under a horizontal fire-tube boiler, as the writer has unfortunately been incorrectly quoted as having stated. For boilers of this type some form of furnace extending partly or entirely in front of the boilers and either hand fired or fed by stokers of the Murphy type would undoubtedly furnish a satisfactory solution to the smoke problem. As elsewhere pointed out the smoke problem is not usually satisfactorily solved with Illinois coals and the horizontal fire-tube boiler. The small unit hardly warrants an automatic stoker. Desire for a cheap plant prevents any special form of furnace and so it is that this kind of a setting frequently proves to be a troublesome smoker.

THE PREPARATION OF COAL FOR SMOKELESS BURNING.

When the coal fed into a furnace is fairly uniform in size it is much easier to burn it without smoke than when it is of different sizes. In all the settings described in this article as smokeless, the coal burned has been of such uniformity as to meet this requirement. The standard commercial sizes are all that are required, such as No. 1, 2, 3, 4 or 5. Take, for instance, the chain-grate stoker; the very principle of its operation, complete consumption of the coal while it travels the length of the furnace, makes it very evident that if small pieces of coal are just consumed, the very large pieces will not be consumed. Just to what extent it will pay to size coal for regular use is not yet very clear, but experiments reported by Mr. W. L. Abbott in a paper before the Western Society of Engineers (September, 1906), makes it evident that the influence of variation in size of the fuel used is of much more importance than has heretofore been generally believed. In these tests the capacity, as well as the efficiency of the plant tested, increased rapidly with the size of the coal used between the average sizes of 0.12 inches and 0.30 inches, after which both these factors dropped again. The following table indicates the general results obtained.

Effect of variation in size of Illinois coal screenings:

Size in inches.	Horsepower.	Efficiency.
.15	350	53
.20	525	60
.25	650	65
.30	725	65
.35	625	63
.40	550	60
.45	500	58
.50	525	58

Whether these results are generally applicable or whether they apply only to the conditions existing in the operation of a single plant it is difficult to say. The plant in which these tests were made corresponds so closely to the plants described in the paper that it would seem very desirable that those operating such plants should take advantage of the results obtained and be sure that the mere matter of inattention to size should not be responsible for a capacity or efficiency loss of from 5 to 10 percent.

The washing of coal, which removes a considerable part of the ash and sulphur, has proved very advantageous to many plants, especially where capacity has been an important consideration. The washing, itself, however, does not make coal burn without smoke. As explained elsewhere, the total volume of volatile combustible distilled per hour from each square foot of grate area must determine those furnace proportions necessary, with the various methods of coal supply to the furnace, which will, with any kind of coal, prevent smoke. The writer desires to mention in this connection that since he began to use washed nut coal in his hot-water residence heater and in his kitchen range, black smoke is seldom seen coming from his chimneys. Previous to the use of this coal the kitchen range pipe required cleaning at least once, sometimes twice each year. It is now three years since this pipe was cleaned. No soot now gathers on the underside of the stove lids as was formerly the case. A fire is easily maintained 8 to 12 hours in the residence heater. Experiments with two types of residence heaters, which are now available for test purposes, are in progress by the experiment station, and it is hoped that more exact information concerning the relative value of various coals used in this kind of furnace will soon be available. The writer confidently believes that we shall soon know how to burn Illinois coals without smoke in residence heating boilers as readily and surely as we now know how to burn it under power-plant boilers.

Briquetted coal offers some opportunity for smoke reduction in certain kinds of furnaces, and certain railroads have reported favorably on its use inside city limits. It does not appear that it can compete with raw coal, certainly not in Illinois, if any consideration is to be given to the cost. There are conditions arising where the question of cost need not be considered—such, for instance, as on naval vessels in time of war. For this reason a series of tests is now being arranged between the steam engineering department of the United

States Navy and the technologic branch of the United States Geological Survey to determine the comparative value of raw and briquetted coal on board several types of naval vessels. In these tests the question of smokeless operation will be a question of careful consideration.

Powdered fuel has been used with much success in places where the coal has not been too high in volatile combustible content, and where the cost of the coal ordinarily used exceeded $5 or $6 a ton. Powdered fuel can be burned without smoke and it can be burned with excellent economy. It cannot, however, be cheaply reduced to a powder.

The writer will welcome suggestions relating to the smoke problem from engineers throughout the country, also drawings, blue prints, etc., and complete and reliable data pertaining to smokeless furnace construction.

Pneumatic Tools for Boiler Shops—IV.

Important Points on the Design, Operation and Care of Pneumatic Drills, Hammers and Hoists which are Used in Boiler Shops.

BY CHARLES DOUGHERTY.

OPERATION OF PNEUMATIC TOOLS.

Under the above title it is intended to mention a few of the uses to which pneumatic tools have been applied in boiler shop practice, and also to call attention to some possible uses. It has occurred to the author that vast benefit would be obtained were some system inaugurated by one of the trade papers, whereby the users of pneumatic tools could describe through its columns novel and useful applications that might not otherwise receive the publicity that they deserve. Aside from the uses and records here described there must certainly have been occasions when necessity invented an application that otherwise might never have seen the light of day, and for this reason it is acknowledged that the uses herein described are by no means all to which pneumatic tools may be applied.

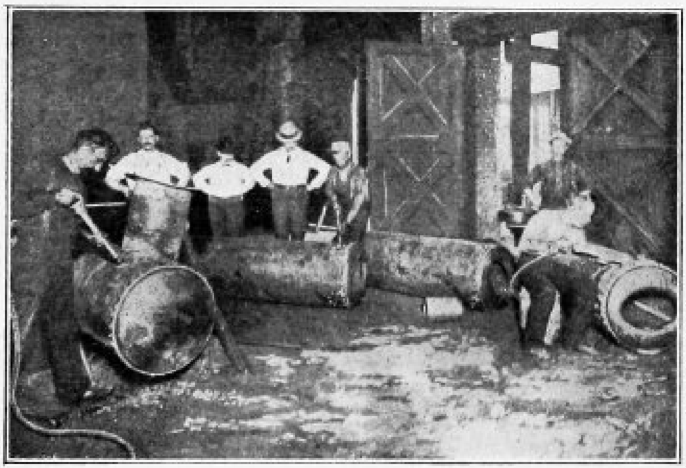


FIG. 1.—RIVETING UP SUPERHEATER DOMES WITH PNEUMATIC HAMMERS.

Aside from the general use of riveting hammers for driving rivets and for which it was the original intention of the makers that the hammers should be applied, they may also be used in conjunction with a swedge in place of the rivet set, for setting up the corners around the mud-ring on the outside and on the inside by substituting a bull nose in place of the original set. This is being done with splendid results in the shops of the Lehigh Valley Railroad Company, at Sayre, Pa. Another way in which they are used in many shops with considerable success, is to fasten a long-stroke hammer rigidly in a perpendicular position by means of straps to a base or upright in the shop directly over the flange blocks. The hammer thus fastened can be used for scarfing small plates, peaning angle iron rings, backing out rivets in small courses, driving rivets, scarfing and welding small band iron rings, and many other uses which arise from time to time in the boiler shop, and where occasion requires hard or light rapid blows.

A yoke riveter can be used for all the purposes described for the long-stroke riveter, with the possible exception of knocking up mud-ring corners. Its uses for course riveting,

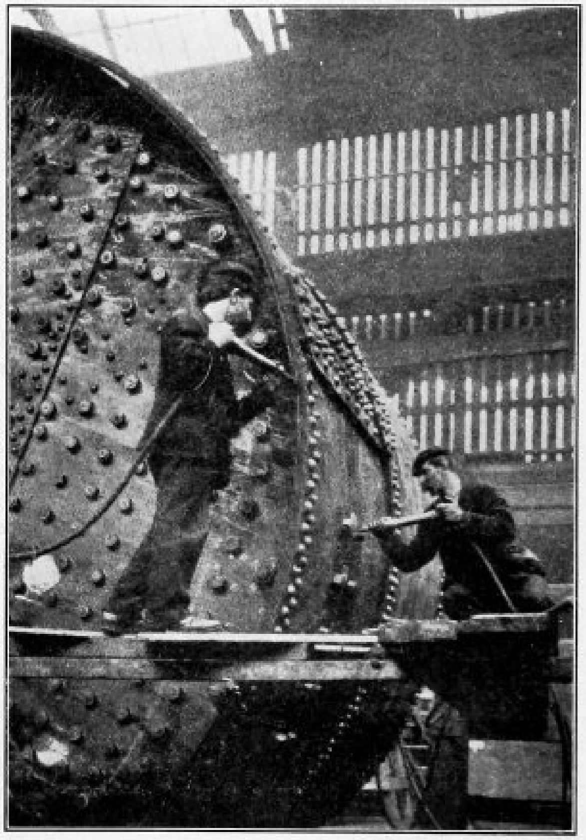


FIG. 2.—CALKING A LARGE MARINE BOILER WITH PNEUMATIC HAMMERS.

angle riveting, smoke-stack work, tank work, etc., are too generally known to necessitate their description here, but it might be of interest to some of the readers to know that it has been used with good effect for jarring the scale from plates either flat or rolled in courses.

A jam riveter, aside from its original purpose, has been used and found handy for cutting off heads and backing out particularly hard rivets, where an occasion for ample backing up presented itself. Another use to which it has been put is driving lap wedges, splitting up timber, etc., and also for expanding tubes.

While the author feels that it is hardly necessary to call attention to the proper method of deriving the best results from the use of chipping hammers, inasmuch as most mechanics are familiar with the principles involved in their use, yet he feels that it might be well to at least mention in a casual way for the benefit of beginners that the proper way to get the most work out of such a tool is to keep the cylinder bushing hard up against the shoulder of the chisel and the chisel hard up against the work. It was difficult to do this with the first pneumatic hammers placed on the market, as it required a man of enormous physical strength to withstand the shock resultant from the recoil of the blow of the piston on the chisel when placed hard against the work. This was the result of imperfect design. These defects have been extensively minimized in the present up-to-date hammers, and it is now comparatively easy for a man of light or medium weight to control the heaviest chipping hammers with the same degree of skill and efficiency as an operator of greater physical strength. The old saying regarding the requisites of a boiler maker that "brute strength and ignorance are the only qualifications necessary," no longer holds good, and we see now every day examples where the intelligent operator, even if physically inferior, can accomplish a great deal more work than one who while having greater physical strength does not apply it to his work through the tool in an intelligent manner.

There is no department of a railroad shop where pneumatic tools can be so effectively and economically employed as the boiler and tank shop. There is hardly an operation in the construction of a boiler, tank, stack or up-take where the pneumatic tool does not play a prominent part; in short, this can be called the pneumatic tool mecca.

Fig. 1 shows clearly the method of driving rivets in the dome of a superheater. The manufacturers of the superheater shown in the illustration had, previous to the use of pneumatic tools, been strong advocates of the old hand method, but after the hydrostatic test, when the boiler was completed by pneumatic tools, they became radical advocates of the pneumatic tool method of construction. Much has been said of the inadvisability of using pneumatic holder-ons on steam-tight work, but this is an example that proves the fallacy of such statements, as not one rivet had to be cut out by reason of the failure of the head of the rivet to be hard up, and all the rivets that could be conveniently reached were held on by pneumatic holder-ons.

That pneumatic chipping hammers are now so constructed as to strike a blow for calking that will stand almost any pressure demanded by the inspectors is amply proven by Fig. 2, which shows a large marine boiler on which all calking was done by pneumatic hammers. Straight seam, leg, head or connection work is easily accomplished and quickly done by the use of the pneumatic chipping hammers, especially cylindrical and straight line work.

For longitudinal seams on butted or lapped pipe work and where the yoke riveter is not available, an excellent method of achieving good results is to form a brace from an angle of sufficient length to take in one course bolted at each end, and placed a sufficient distance from the shell to allow a free movement of the hammer. This acts as a guide and rest for the operator, as is shown in Fig. 3.

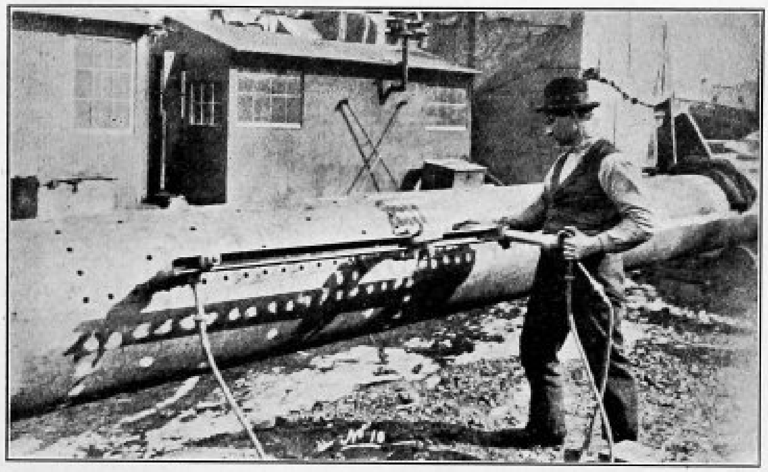


FIG. 3.—SPECIAL ATTACHMENT FOR RIVETING PIPE WORK.

The pneumatic drill is used in the boiler shop for all classes of drilling, reaming, tapping, running in stay-bolts, rolling flues, etc. Fig. 4 shows the application of the rotary drill on marine furnace work. It is so arranged on a rig that it can be utilized at any point of the furnace without the necessity of blocking. For tapping stay-bolt holes in locomotive fire-boxes, the drill may be suspended from an arm mounted on top of the boiler, or it may be carried by a light overhead trolley, and counterbalanced with a weight so that the only effort required on the part of the operator is that necessary to hold the drill up to its work. When used for drilling, a pneumatic drill is usually secured in place and braced by an "old man" or heavy bar of iron bolted to the work at right angles to the line of the drill, as shown in Fig. 5.

While this article is in the main confined to pneumatic riveters and drills, in view of the fact that they are the most extensively used in boiler shop practice, we might mention that all up-to-date shops are equipped with a stay-bolt breaker, which, while somewhat cumbersome, is used extensively, aside from its original purpose of cutting out stay-bolts, for cutting off rivets, etc.

Some records that have been made with pneumatic drills might prove of interest to the reader, but we feel sure that since these records were made they have been exceeded by others. We find records of where a pneumatic drill drilled fifty-four 15/16-inch diameter holes in 70 minutes, through ¾-inch plate on the flange of a marine boiler, the furnace being in position. This same work previously took by hand 8½ hours. With a smaller size pneumatic drill a ⅞-inch hole was drilled through ½-inch plate in 22 seconds. This work took 4 minutes with a flexible shaft and about 10 minutes with a ratchet drill. Another drill made an average of 30 seconds each drilling locomotive tube holes in copper 1⅞-inch outside diameter under 70 pounds air pressure. In drilling test or telltale holes in stay-bolts, two men with two small pneumatic breast drills can drill 140 stay-bolts per hour. In tapping holes in a fire-box, it takes about 32 seconds per hole with a pneumatic drill of suitable size, 2 minutes with a flexible shaft and from 5 to 6 minutes by hand. Two men with two drills can tap out the holes and screw in 700 stay-bolts in a fire-box in 14 hours. For reaming purposes the pneumatic drill, especially that of the rotary type, will do the work in about one-third of the time required by a flexible shaft and one-sixth of the time required by a hand ratchet.

That the pneumatic riveting hammer as applied to steam-tight work has come to stay is confirmed by a glance at some of the following records: In riveting on a standard fire-box leg containing 253 ¾-inch rivets, a long-stroke hammer will do the entire job in 9 hours. The same job by hand took 15 hours. We find another instance of where $1\frac{1}{4}$-inch rivets were driven in a boiler which stood 360 pounds pressure with a pneumatic riveting hammer at about one-third the cost of old methods. We also have a report from a railroad shop of a mud-ring being riveted on a consolidation locomotive by the air hammer at a saving over hand riveting of 67 percent.

THE CARE OF PNEUMATIC TOOLS.

The subject of the care of pneumatic tools is apparently such a trivial matter to a vast majority of users, where its importance is of such magnitude, threatening as it does the very life of the tool, that this subject is treated with other than ordinary comment. It is doubtful if any piece of machinery which shows such large returns for its original investment, receives such abuse as do pneumatic tools. It is a question whether any other piece of machinery pays a greater profit on its cost than pneumatic tools, when their highest efficiency is maintained by being kept in good working condition. The first essential to the maintenance of pneumatic tools is that they be kept thoroughly clean and oiled. This is of the greatest importance. Each pneumatic hammer operated by valves has of necessity an intricate series of holes or ports in the valve, valve block and cylinder. There are no superfluous holes. Each is there for a purpose, no matter how small or seemingly how inconsequential. It will be seen, therefore, from this, that the blocking of one or several of these holes or ports will impair the efficiency of the tool, consequently, the great necessity of keeping them absolutely clean and free from dirt, grit or any other foreign substance that would have a tendency to obstruct the free passage of air, or interfere in any way with the moving parts. The same advice is given as regards drills.

The designers of these tools are each experts in their respective lines and know the value of each and every part in the tool, and the relation of one part to another. Notwithstanding the fact that each manufacturer of pneumatic tools issues instructions with every tool shipped from his factory, regarding the care of the tools, it is common knowledge that the vast majority of users pay no attention whatever to these instructions. It is the more to be regretted that such advice is not heeded, coming, as it does, from those who are desirous of benefiting their patrons and representing the opinion of experts. We all know how much we value the words of a specialist in sickness, and we value it so because we must pay highly for it. The pneumatic tool user, however, very seldom appreciates the advice given by the manufacturer of pneumatic tools (in other words, the advice of the specialist) until such time as the tool begins to show signs of sickness, or in the parlance of the boiler shop refuses to "stand up," then they send for the specialist with a long letter of complaint to the manufacturer about the poor tools that are being sent out. The manufacturer sends a specialist in the form of a salesman or pneumatic tool demonstrator, who simply puts into the practice the advice given by the manufacturer at the time the tools were shipped, namely, *keep the tools well cleaned, free from dirt and well oiled*. The result is that the tools are again in good working condition, but with considerable loss of valuable time to the user, and it is strange to say that notwithstanding the lesson thus taught, some of the users revert to the old practice and neglect cleaning or oiling the tools and keeping them in proper shape for service.

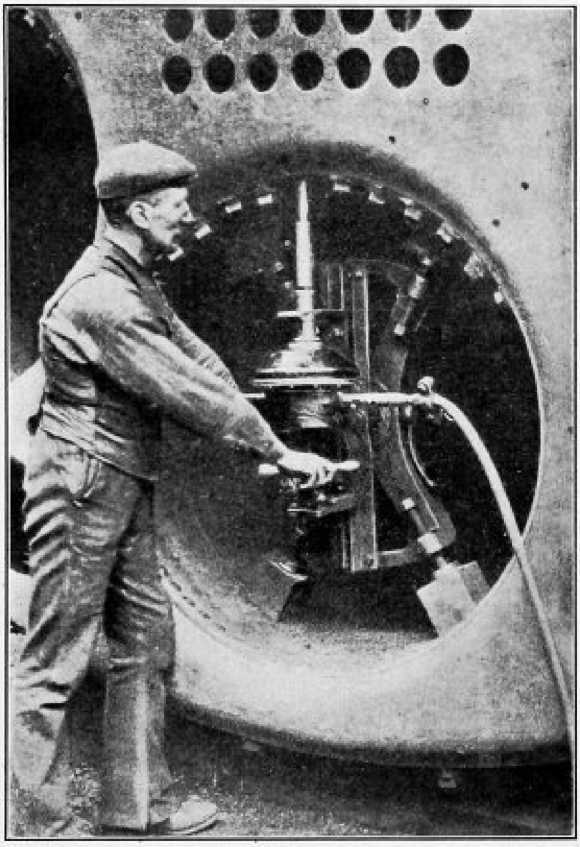


FIG. 4.—DEVICE FOR CENTERING A DRILL IN A CIRCULAR FURNACE.

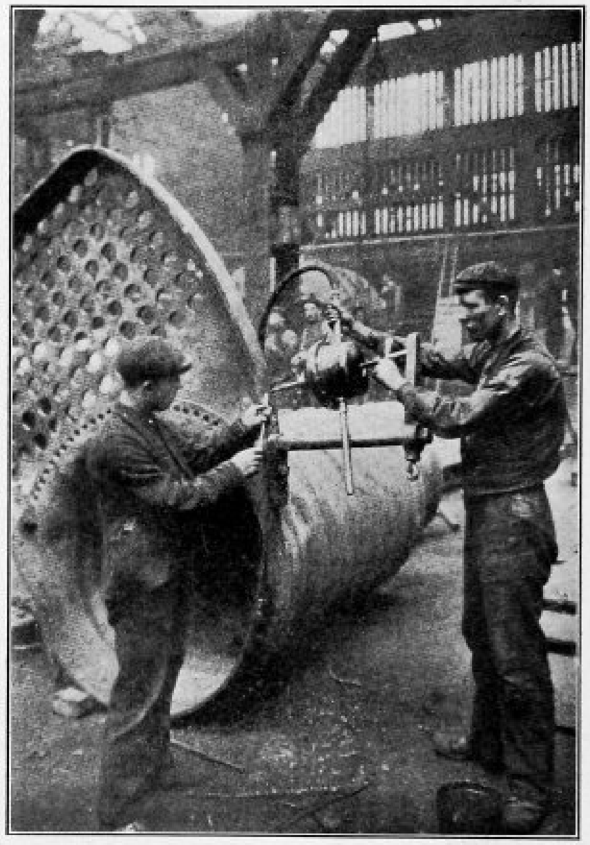


FIG. 5.—ORDINARY TYPE OF "OLD MAN" FOR HOLDING A DRILL.

It is essential to the good working and durability of all pneumatic tools that they be kept clean and well oiled. Do not wait until the tool has stopped working on account of any foreign substance or of the gumming of poor oil. If, however, the tool has stopped working, a good thing to do is to immerse the entire tool in a bath of kerosene oil, allowing it to stay there for such length of time as may be necessary for the kerosene to cut or loosen the foreign substance from the mechanism of the tool, then remove the tool from the kerosene bath, attach a hose and blow out thoroughly. Do this two or three times until you are assured that the tool is free from all obstructions. Then oil the machinery thoroughly with a good, light-bodied machine oil, of which there are a few good brands on the market. Allow the tool to run free for a little while, until such time as the light-bodied machine oil has been blown through every working part of the mechanism. Be sure that the oil used is not a heavy oil that will become gummed from the cold air. Most of the heavy oils do this, and as a result the tool very often becomes inoperative, whereas with a light oil this would be avoided.

An excellent method of guaranteeing the life of all pneumatic tools and one that should be in vogue in all boiler shops, is to construct a light tank capable of holding enough kerosene oil to totally cover as many tools as may be in use in the shop. Have the tools immersed in this bath nightly and blown out thoroughly before oiling in the morning. To insure the long life of a tool it should be oiled frequently, preferably, once every 2 hours for a drill, and once an hour for a hammer, and certainly not less than three times a day for either a drill or a hammer.

While the same general rules regarding care of pneumatic tools may be applied to the care of pneumatic hoists, there is one thing that should be added. All pneumatic hoists are so constructed or incased as to be made dust proof, hence there is less need for frequent inspection of those in use in boiler shops or dusty roundhouses. It is good practice to go over pneumatic hoists very carefully at least once a week, giving them a thorough blowing down with the air nozzle, to remove all accumulations of dirt which may have settled on the ends around exposed parts, and from which dirt is liable to drop from time to time into the gears and moving parts, with a corresponding tendency to cut or injure the mechanism. Where it is not practicable to occasionally inspect the hoist, or where time is limited, it is advisable that kerosene should be blown through it from time to time, and that it should be frequently oiled.

Yoke and jam riveters and holder-ons, most of which have but one moving part, do not require such careful attention as other pneumatic tools, but, nevertheless, should be kept reasonably clean and well oiled. For, to quote the words of a prominent expert and inventor of pneumatic tools, "It will handsomely repay any user of pneumatic hammers to keep the inside of the tools as clean and well oiled as the sportsman does his gun."

In conclusion it may be well to impress a few facts upon the users of pneumatic tools, which if adhered to may be the means of avoiding needless worry.

Don't abuse the tool; treat it as you would any high-class piece of machinery.

Don't throw it down as you would a piece of scrap iron; by doing so you may cause serious injury.

Don't use a light tool on heavy work.

Don't run a chipping or calking hammer without first inserting the tool in the nose bushing—in other words, don't run it light.

Don't neglect to keep the tool "hard up" against the work. This applies to riveters also.

Don't start a tool that has been laying around in the dirt until it is thoroughly cleaned.

Don't attempt to "monkey" with a tool when it gets out of order, if you know nothing about its construction.

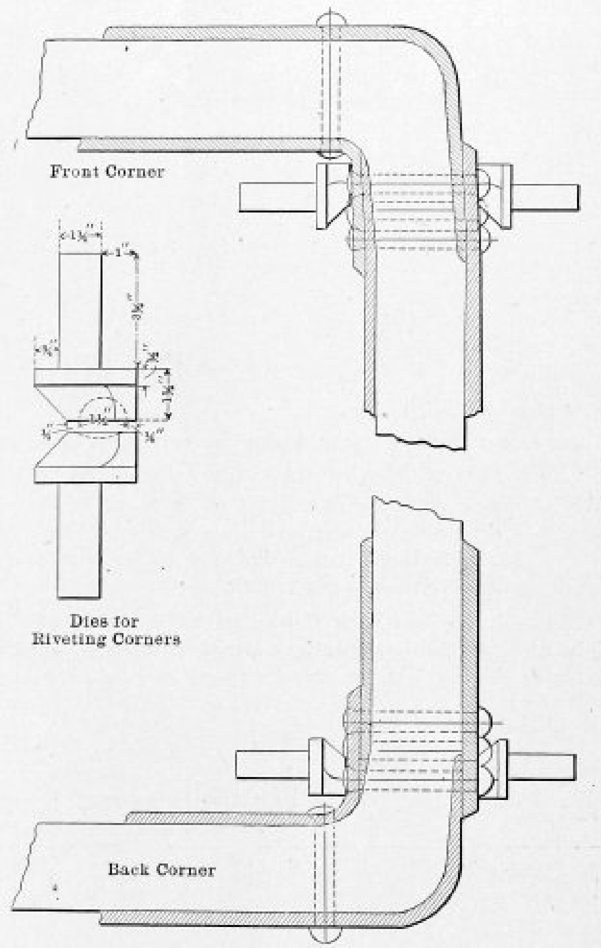
Don't run a hammer or drill unless all parts are tightened up.

Don't wipe a piston with dirty waste or a dirty rag; dip it in oil and use your hand.

Don't neglect to keep the tool clean, free from dirt and well oiled.

Off-Set Dies for Corner Work.

Riveting up the corners of mud rings in locomotive boilers is an operation which is usually performed by hand, simply from the fact that there is not enough space to accommodate the rivet dies, which are ordinarily used on a "bull" machine or portable riveter. The illustration shows how by the use of special dies this work may be done on a machine, thus saving a vast amount of time. The dies are off-set and placed loosely in the riveter so that they can be readily turned for driving the rivets in opposite corners. A flat or button head die may be used as desired. These dies are used in the Milwaukee shops



DETAILS OF OFF-SET RIVET DIES AND THEIR APPLICATION TO THE CORNER RIVETS IN THE MUD-RING OF A LOCOMOTIVE FIRE-BOX.

of the Chicago, Milwaukee & St. Paul Railway Company, and we are informed by Mr. A. N. Lucas, general foreman boiler maker of these shops, that the twelve corner rivets, three in each corner of the mud ring, can be driven up with one machine in from twenty to thirty minutes at a cost of from twenty-five to thirty-five cents.

With the old method of driving these rivets by hand it took four men from four to five hours time at a cost of from $4.50 to $5. Thus there is a great saving gained, and an experience of three years has shown that very good results can be obtained by this method on both old and new work.

The total production of coal throughout the world in 1906 has been estimated at 1,106,479,000 short tons, of which the United States produced 414,157,000 tons, or 37.4 percent of the total. The United States produced 43.7 percent more than Great Britain and 85 percent more than Germany.

Lloyd's Register Boiler Rules.*

Rules for Determining the Working Pressure to be Allowed in New Boilers.

CYLINDRICAL SHELLS OF IRON BOILERS.

The strength of circular shells of iron boilers to be calculated from the strength of the longitudinal joints by the following formula:

$$\frac{C \times T \times B}{D} = \text{working pressure},$$

where C = coefficient as per following table.
T = thickness of plate in inches.
D = mean diameter of shell in inches.
B = percentage of strength of joint found as follows—the least percentage to be taken:

For plate at joint, $B = \frac{p - d}{p} \times 100.$

For rivets at joint, $B = \frac{n \times a}{p \times T} \times 100$; with iron rivets in iron plates with punched holes.

$B = \frac{n \times a}{p \times T} \times 90$; with iron rivets in iron plates with drilled holes.

(In case of rivets being in double shear, 1.75 a is to be used instead of a.

Where p = pitch of rivets.
d = diameter of rivets.
a = sectional area of rivets.
n = number of rows of rivets.

MEM.—In any case where the strength of the longitudinal joint is satisfactorily shown by experiment to be greater than given by this formula, the actual strength may be taken in the calculation.

TABLE OF COEFFICIENTS.—IRON BOILERS.

DESCRIPTION OF LONGITUDINAL JOINT.	For Plates ½ Inch Thick and Under.	For Plates ½ Inch and Above ½ Inch.	For Plates Above ¾ Inch Thick.
Lap joint, punched holes	155	165	170
Lap joint, drilled holes	170	180	190
Double butt-strap joint, punched holes	170	180	190
Double butt-strap joint, drilled holes	180	190	200

NOTE—The inside butt strap to be at least three-fourths of the strength of the longitudinal joint.

CYLINDRICAL SHELLS OF STEEL BOILERS.

The strength of cylindrical shells of steel boilers is to be calculated from the following formula:

$$\frac{C \times (T - 2) \times B}{D} = \text{working pressure in pounds per square inch.}$$

Where D = mean diameter of shell in inches.
T = thickness of plate in sixteenths of an inch.
C = 22 when the longitudinal seams are fitted with double butt straps of equal width.
C = 21.55 when they are fitted with double butt straps of unequal width, only covering on one side the reduced section of plate at the outer lines of rivets.
C = 20.5 when the longitudinal seams are lap joints.

* Extracts from rules published in 1907-8.

If the minimum tensile strength of shell plates is other than 28 tons per square inch, these values of C should be correspondingly modified.

B = the least percentage strength of longitudinal joint, found as follows:

For plate at joint, $B = \frac{p - d}{p} \times 100.$

For rivets at joint, $B = \frac{n \times a}{p \times t} \times 85$ where steel rivets are used.

$B = \frac{n \times a}{p \times t} \times 70$ where iron rivets are used.

Where p = pitch of rivets in inches.
t = thickness of plate in inches.
d = diameter of rivet holes in inches.
n = number of rivets used per pitch in the longitudinal joint.
a = sectional area of rivet in square inches.

(In case of rivets in double shear 1.75 a is to be used instead of a.)

NOTE—The inside butt strap to be at least three-fourths of the strength of the longitudinal joint.

NOTE—For the shell plates of superheaters or steam chests enclosed in the up-takes or exposed to the direct action of the flame, the coefficients should be two-thirds of those given above.

Proper deductions are to be made for openings in shell.

All manholes in circular shells to be stiffened with compensating rings.

The shell plates under domes in boilers so fitted to be stayed from the top of the dome or otherwise stiffened.

STAYS.

The strength of stays supporting flat surfaces is to be calculated from the smallest part of the stay or fastening, and the strain upon them is not to exceed the following limits, namely:

IRON STAYS.

For stays not exceeding 1½ inches smallest diameter, and for all stays which are welded, 6,000 pounds per square inch; for unwelded stays above 1½ inches smallest diameter, 7,500 pounds per square inch.

STEEL STAYS.

For screw stays not exceeding 1½ inches smallest diameter, 8,000 pounds per square inch; for screw stays above 1½ inches smallest diameter, 9,000 pounds per square inch. For other stays not exceeding 1½ inches smallest diameter, 9,000 pounds per square inch, and for stays exceeding 1½ inches smallest diameter, 10,400 pounds per square inch. No steel stays are to be welded.

STAY TUBES.

The stress is not to exceed 7,500 pounds per square inch.

FLAT PLATES.

The strength of flat plates supported by stays to be taken from the following formula:

$$\frac{C \times T^2}{P^2} = \text{working pressure in pounds per square inch.}$$

Where T = thickness of plate in sixteenths of an inch.
P^2 = square of pitch in inches; if the pitch in the rows is not equal to that between the rows, then the mean of the squares of the two pitches is to be taken.
C = 90 for iron or steel plates 7/16 thick and under, fitted with screw stays with riveted heads.

$C = 100$ for iron or steel plates above 7/16 thick, fitted with screw stays with riveted heads.
$C = 110$ for iron or steel plates 7/16 thick and under, fitted with stays and nuts.
$C = 120$ for iron plates above 7/16 thick, and for steel plates above 7/16 and under 9/16 thick, fitted with screw stays and nuts.
$C = 135$ for steel plates 9/16 thick and above, fitted with screw stays and nuts.
$C = 140$ for iron plates fitted with stays with double nuts.
$C = 150$ for iron plates fitted with stays, with double nuts and washers outside the plates, of at least one-third of the pitch in diameter and one-half the thickness of the plates.
$C = 160$ for iron plates fitted with stays, with double nuts and washers riveted to the outside of the plates, of at least two-fifths of the pitch in diameter and one-half the thickness of the plates.
$C = 175$ for iron plates fitted with stays, with double nuts and washers riveted to the outside of the plates, when the washers are at least two-thirds of the pitch in diameter and of the same thickness as the plates.

For iron plates fitted with stays, with double nuts and doubling strips riveted to the outside of the plates, of the same thickness as the plates, and of a width equal to two-thirds the distance between the rows of stays, C may be taken as 175 if P is taken to be the distance between the rows, and 190 when P is taken to be the pitch between the stays in the rows.

For steel plates, other than those for combustion chambers, the values of C may be increased as follows:

$C = 140$	increased to	175.
150	"	185.
160	"	200.
175	"	220.
190	"	240.

If flat plates are strengthened with doubling plates securely riveted to them, having a thickness of not less than two-thirds of that of the plates, the strength to be taken from

$$\frac{C \times (T + t/2)^2}{P^2} = \text{working pressure in pounds per square inch;}$$

where t = thickness of doubling plates in sixteenths, and C, T and P are as above.

NOTE—In the case of front plates of boilers in the steam space these numbers should be reduced 20 percent unless the plates are guarded from the direct action of the heat.

For steel tube plates in the nest of tubes the strength to be taken from

$$\frac{140 \times T^2}{P^2} = \text{working pressure in pounds per square inch;}$$

where T = the thickness of the plate in sixteenths of an inch.
P = the mean pitch of stay tubes from center to center.

For the wide water spaces between the nests of tubes the strength to be taken from

$$\frac{C \times T^2}{P^2} = \text{working pressure in pounds per square inch;}$$

where P = the horizontal distance from center to center of the bounding rows of tubes, and

$C = 120$ where the stay tubes are pitched with two plain tubes between them, and are not fitted with nuts outside the plates.
$C = 130$ if they are fitted with nuts outside the plates.
$C = 140$ if each alternate tube is a stay tube not fitted with nuts.
$C = 150$ if they are fitted with nuts outside the plates.
$C = 160$ if every tube in these rows is a stay tube and not fitted with nuts.
$C = 170$ if every tube in these rows is a stay tube, and each alternate stay tube is fitted with nuts outside the plates.

The thickness of tube plates of combustion chambers in cases where the pressure on the top of the chambers is borne by these plates is not to be less than that given by the following rule:

$$T = \frac{P \times W \times D}{1750 \times (D - d)}$$

Where P = working pressure in pounds per square inch.
W = width of combustion chamber between plates in inches.
D = horizontal pitch of tubes in inches.
d = inside diameter of plain tubes in inches.
T = thickness of tube plates in sixteenths of an inch.

GIRDERS.

The strength of girders supporting the tops of combustion chambers and other flat surfaces to be taken from the following formula:

$$\frac{C \times d^2 \times T}{(L - P) \times D \times L} = \text{working pressure in pounds per square inch.}$$

Where L = width between the tube plate and back plate of chamber.
P = pitch of stays in girders.
D = distance from center to center of girders.
d = depth of girders at center.
T = thickness of girder at center. All these dimensions to be taken in inches.

For wrought iron—
$C = 6{,}000$ if there is one stay to each girder.
$C = 9{,}000$ if there are two or three stays to each girder.
$C = 10{,}000$ if there are four or five stays to each girder.
$C = 10{,}500$ if there are six or seven stays to each girder.
$C = 10{,}800$ if there are eight stays or above to each girder.

For wrought steel—
$C = 7{,}110$ if there is one stay to each girder.
$C = 10{,}660$ if there are two or three stays to each girder.
$C = 11{,}850$ if there are four or five stays to each girder.
$C = 12{,}440$ if there are six or seven stays to each girder.
$C = 12{,}800$ if there are eight stays or above to each girder.

If the minimum tensile strength of girder plates is other than 28 tons per square inch, these values of C shall be correspondingly modified.

CIRCULAR FURNACES.

The strength of plain furnaces to resist collapsing to be calculated as follows:

Where the length of the plain cylindrical part of the furnace exceeds 120 times the thickness of the plate, the working pressure is to be calculated by the following formula:

$$\frac{1{,}075{,}200 \times T^2}{L \times D} = \text{working pressure in pounds per square inch;}$$

where the length of the plain cylindrical part of the furnace is less than 120 times the thickness of the plate, the working pressure is to be calculated by the following formula:

$$\frac{50 \times (300\,T - L)}{D} = \text{working pressure in pounds per square inch.}$$

Where D = outside diameter of furnace in inches.
T = thickness of plate in inches.
L = length of plain cylindrical part in inches, measured from the centers of the rivets connecting the furnaces to the flanges of the end and tube plates, or from the commencement of the curvature of the flanges of the furnace where it is flanged or fitted with Adamson's rings.

In the furnaces referred to below the formulæ given are applicable if the steel used has a tensile strength of not less than 26 nor more than 30 tons per square inch. If the material of furnaces has a less tensile strength than 26 tons per square inch, then for each ton per square inch which the minimum tensile strength falls below 26, the coefficient is to be correspondingly decreased by 1/26 part.

The strength of corrugated furnaces made on Fox's, Morison's, Deighton's or Beardmore's plan to be calculated from

$$\frac{1{,}259 \times (T - 2)}{D} = \text{working pressure in pounds per square inch.}$$

The strength of spirally corrugated furnaces is to be calculated from the following formula:

$$\frac{912 \times (T - 2)}{D} = \text{working pressure in pounds per square inch.}$$

Where T = thickness of plate in sixteenths of an inch, and
D = outside diameter of corrugated furnaces in inches.

The strength of Improved Purve's furnaces with ribs 9 inches apart, and of Brown's cambered furnaces with ribs either 8 or 9 inches apart, to be calculated from the following formula:

$$\frac{1{,}160 \times (T - 2)}{D} = \text{working pressure in pounds per square inch.}$$

Where T = thickness of plate in sixteenths of an inch, and
D = smallest outside diameter of furnaces in inches.

The strength of the Leeds forge bulb furnace is to be calculated from the following formula:

$$\frac{1{,}259 \times (T - 2)}{D} = \text{working pressure in pounds per square inch.}$$

Where T = thickness of plate in sixteenths of an inch, and
D = smallest outside diameter in inches.

The strength of Holmes' patent furnaces, in which the corrugations are not more than 16 inches apart from center to center, and not less than 2 inches high, to be calculated from the following formula:

$$\frac{945 \times (T - 2)}{D} = \text{working pressure in pounds per square inch.}$$

Where T = thickness of plain portions of furnaces in sixteenths of an inch.
D = outside diameter of plain parts of the furnace in inches.

DONKEY BOILERS.

The iron used in the construction of the fire-boxes, up-takes and water tubes of donkey boilers shall be of good quality and to the satisfaction of the surveyors, who may in any cases where they deem it advisable apply the following tests:

THICKNESS OF PLATES.	TO BEND COLD THROUGH AN ANGLE OF	
	With the Grain.	Across the Grain.
5/16	80°	45°
6/16	70°	35°
7/16	55°	25°
8/16	40°	20°

The material to stand bending hot to an angle of 90 degrees, over a radius not greater than one and one-half times the thickness of the plates.

GENERAL REMARKS ABOUT BOILERS UNDER CONSTRUCTION.

The surveyors will be guided in fixing the working pressure by the tables and formulæ annexed.

Any novelty in the construction of the machinery or boilers to be reported to the committee.

The boilers, together with the machinery, to be inspected at different stages of construction.

All the holes in steel boilers should be drilled, but if they be punched the plates are to be afterwards annealed.

All plates that are dished or flanged, or in any way heated in the fire for working, except those that are subjected to a compressive stress only, are to be annealed after the operations are completed.

No steel stays are to be welded.

Unless otherwise specified, the rules for the construction of iron boilers will apply equally to boilers made of steel.

The boilers to be tested by hydraulic pressure, in the presence of the engineer-surveyor, to twice the working pressure, and carefully gaged while under test.

Two safety valves to be fitted to each boiler and loaded to the working pressure in the presence of the surveyor. In the case of boilers of greater working pressure than 60 pounds per square inch, the safety valves may be loaded to 5 pounds above the working pressure. If common valves are used, their combined areas to be at least half a square inch to each square foot of grate surface. If improved valves are used, they are to be tested under steam in the presence of the surveyor; the accumulation in no case to exceed 10 percent of the working pressure.

An improved safety valve also to be fitted to the superheater.

In winch boilers one safety valve will be allowed, provided its area be not less than half a square inch per square foot of grate surface.

Each valve to be arranged so that no extra load can be added when steam is up, and to be fitted with easing gear which must lift the valve itself. All safety-valve spindles to extend through the covers and to be fitted with sockets and cross handles, allowing them to be lifted and turned round in their seats, and their efficiency tested at any time.

Stop valves to be fitted so that each boiler can be worked separately.

Each boiler to be fitted with a separate steam gage, to accurately indicate the pressure.

Each boiler to be fitted with a blow-off cock independent of that on the vessel's outside plating.

The machinery and boilers are to be securely fixed to the vessel to the satisfaction of the surveyor.

SUMMARY.

The preceding rules are summarized in the following short table, in which the method has been carried out of indicating all such dimensions as are measured in inches by capitals, such as are measured in sixteenths of an inch by small letters:

C and C' = coefficients.
$W\ P$ = permissible working pressure.
B and B' = percentage of joint respectively of plate and rivets.
N = number of rivets included within one pitch of external row.
T and t = thicknesses of plates measured respectively in inches and in sixteenths of an inch.
P = pitch in inches of rivets or stays in flat plates, or tubes in tube plates.
P_c = distance apart of girders or cross pitch of stays in inches.
D = mean diameter of shells and diameter of furnaces in inches, measured as follows: For all plain furnaces, or made with ribs (Purves's), with flanges (Adamson's rings) or for Holmes' furnaces, the outside diameter of the plain cylindrical part is to be taken, and the thickness of the plates measured at these parts. For Fox's and Morison's corrugated furnaces the extreme external diameter is to be taken.
D and D_1 = effective external and internal diameters of plain or stay tubes and effective diameter of rivets, or of stays, in inches.
L or L' = length of plain cylindrical parts of furnaces measured respectively in inches or feet.
L = length of girders measured in inches = internal distance between tube and back plates.
H = depth of girders measured in inches.
A = sectional area of stays or stay tubes, or of rivets, in square inches.
ΣA = sum of areas of holes in tube plate in square inches.

Iron boiler shells—

$$W\ P = C \times (B \text{ or } B') \times \frac{T}{D} \text{ or } C' \times (B \text{ or } B') \times \frac{t}{D}$$

TABLE OF COEFFICIENTS.

JOINT.	DOUBLE BUTT STRAPS.					
Plates.	C.			C'.		
Thickness of Plates.	½ Inch.	¾ Inch.	Above.	½ Inch.	¾ Inch.	Above.
Punched	170	180	190	10.61	11.24	11.87
Drilled	180	190	200	11.24	11.87	12.50

JOINT.	LAP JOINTS.					
Plates.	C.			C'.		
Thickness of Plates.	½ Inch.	¾ Inch.	Above.	½ Inch.	¾ Inch.	Above.
Punched	155	165	170	9.68	10.31	10.61
Drilled	170	180	190	10.61	11.24	11.87

Steel boiler shells—

$$W\ P = C \times (B \text{ or } B') \times \frac{t-2}{D}$$

TABLE OF COEFFICIENTS C.

TENACITY OF STEEL, TONS.	26	27	28	29	30	31	32
Lap joints	19.03	19.76	20.50	21.23	21.96	22.69	23.42
Butt straps of unequal widths	19.73	20.49	21.25	22.01	22.76	23.52	24.28
Butt straps of equal widths	20.43	21.21	22.00	22.78	23.57	24.35	25.14

RIVETED JOINTS.

$$\text{Percentage of plate } B = \frac{P-D}{P} \times 100.$$

$$\text{Percentage of rivets } B' = C \times N \frac{A}{P \times T} \text{ or } C' \times N \times \frac{D^2}{P \times T}$$

TABLE OF COEFFICIENTS.

MATERIAL OF		DOUBLE BUTT STRAPS.		LAP JOINTS.	
Plate.	Rivet.	C.	C'.	C.	C'.
Iron, punched	Iron	175.0	137.4	100	78.5
Iron, drilled	Iron	157.5	123.8	90	70.7
Steel, punched	Iron	122.5	96.3	70	55.0
Steel, drilled	Steel	148.7	116.8	85	66.7

Stayed flat plates—

$$\text{If pitches are equal } W\ P = \frac{C \times t^2}{P^2}$$

$$\text{If pitches are unequal } W\ P = \frac{2 \times C \times t^2}{P^2 + P_c^2} = \frac{2 \times C \times t^2}{\Delta_2},$$

where Δ is the diameter of the greatest inscribed circle.

TABLE OF COEFFICIENTS—C.	Iron.	Steel.
Stay ends riveted, plates up to $^7/_{16}$ inch	90	90
Stay ends riveted, plates above $^7/_{16}$ inch	100	100
Stay ends nutted, plates up to $^7/_{16}$ inch	110	110
Stay ends nutted, plates above $^7/_{16}$ inch	120	120
Stay ends nutted, plates $^9/_{16}$ inch thick and above	120	135
Double nuts	140	175
Double nuts and washers ($^1/_3$P x $^1/_2$T)	150	185
Double nuts and riveted washers ($^2/_3$P x $^1/_2$T)	160	200
Double nuts and riveted washers ($^2/_3$P x T)	175	220
Double nuts and doubling strips ($^2/_3$P x T), lengthways	190	240
Tube plate	140	140
Tube plate between nests of tubes	Beaded	Nutted
When there are two plain tubes between stays	120	130
When there is one plain tube between stays	140	150
When every tube is a stay tube	160	170

Doubling plates W. P. $= C\ \frac{(2t+t')^2}{2t}$ } t' is the thickness of the doubling plate in sixteenths of an inch.

STAYS.

Stays—

$$W\ P = C \times \frac{A}{P \times P_c} \text{ or } C' \times \frac{D^2}{P \times P_c}$$

Stay tubes—

$$W\ P = C \times \frac{A}{P \times P_c - \Sigma A} \text{ or } C' \times \frac{D^2 - D_1}{P \times P_c - \Sigma A}$$

TABLE OF COFFICIENTS.	C.		C'.	
	Iron.	Steel.	Iron.	Steel.
Screwed stays up to 1½ inch effective diameter	6,000	8,000	4,712	6,283
Screwed stays above 1½ inch effective diameter	7,500	9,000	5,891	7,068
Stay tubes	7,500	7,500	5,890	5,890

Tube plates— $W\ P = \dfrac{1,600\ (P - D_1')\ t}{L \times P}$

Girders— $W\ P = C \times \dfrac{H^2 T}{L \times (L - P) \times P_c}$

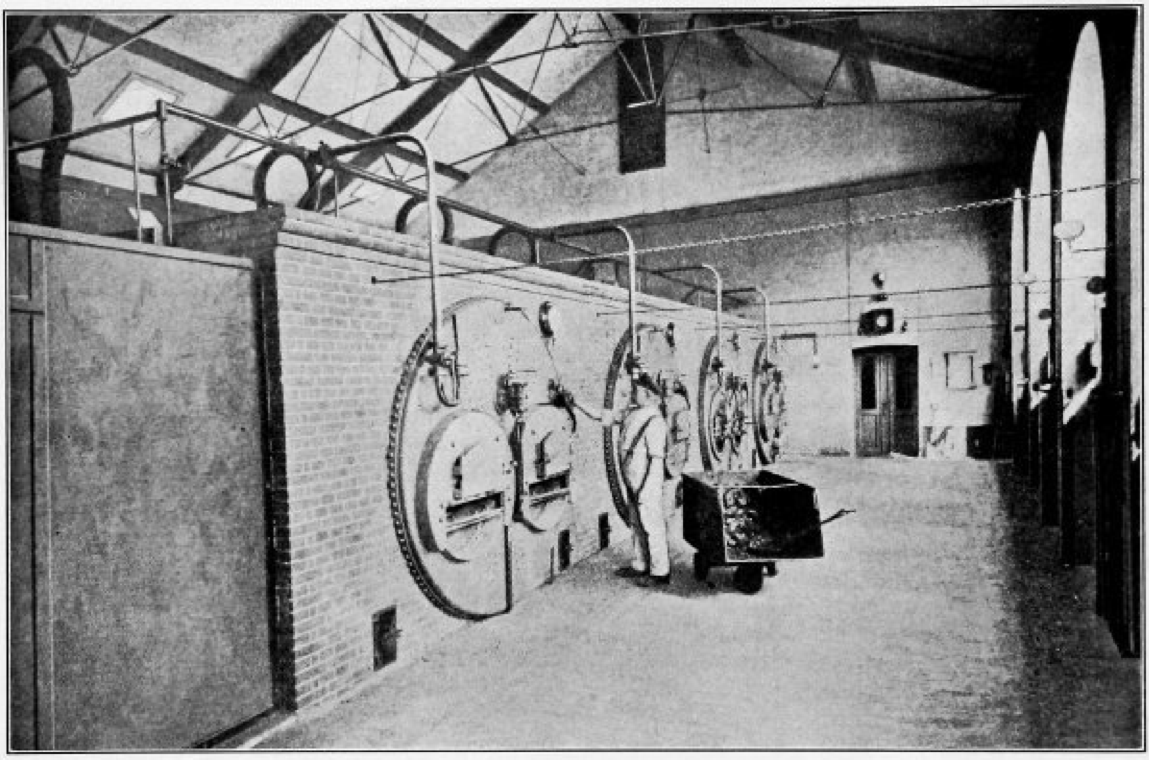
TABLE OF COFFICIENTS.	C.	
Number of Stays per Girder.	Iron.	Steel.
One	6,000	7,110
Two or three	9,000	10,060
Four or five	10,000	11,850
Six or seven	10,500	12,440
Eight or more	10,800	12,800

Boilers for Mills and Works in England.

Opinions of English Engineers as Reported by an Occasional Correspondent.

The opinions of English engineers and works managers on boiler construction may be of interest to American readers. The type of boiler in general use for all large works and factories in England is known as the Lancashire boiler—a two-flued variety. For more than half a century it has altered very little, but pressures have steadily increased from 20 to 30 pounds, and even less, up to 200 pounds per square inch, with 100 pounds as the most usual figure for new boilers. The dimensions of the boiler in use in England have also increased somewhat. This combination of large diameter of shell and high steam pressure has involved many practical difficulties in construction, and has induced some mill and works owners to favor the water-tube boiler. Other developments in boiler construction have had a limited vogue. For a time cross tubes placed in the flues seemed likely to become very general, but experience has told against them, and it is comparatively seldom that they are now fitted in England. With dirty or impure water they are likely to cause corrosion, and even with pure water they increase the difficulties of cleaning and of inspection. Their value, from the point of view of increased efficiency, is also in the opinion of English engineers debatable. In general engineering the construction of boilers should be as simple as is consistent with satisfactory and efficient working; this principle applies with particular force to boilers, because time, of necessity, warps and corrodes them, and thorough inspection can seldom be made more frequently than twice or thrice a year.

The difficulties of the boiler maker increase considerably with the steam pressure and the diameter of the shell. Both these call for greater thickness in the boiler plates and for more rigid riveted joints, which tend to make the boiler stiff and unyielding. But the high-pressure Lancashire boiler in general



TYPICAL INSTALLATION OF ENGLISH MILL BOILERS.

FURNACES.

Plain furnaces when L exceeds 120 T—

$$W\ P = \frac{1,075,200 \times T}{D \times L} = \frac{4,200 \times t^2}{D \times L} = \frac{350 \times t^2}{D \times L'}$$

Plain furnaces when L is less than 120 T—

$$W\ P = \frac{50 \times (300\ T - L)}{D} = \frac{600}{D}\ (1.5625 \times t - L')$$

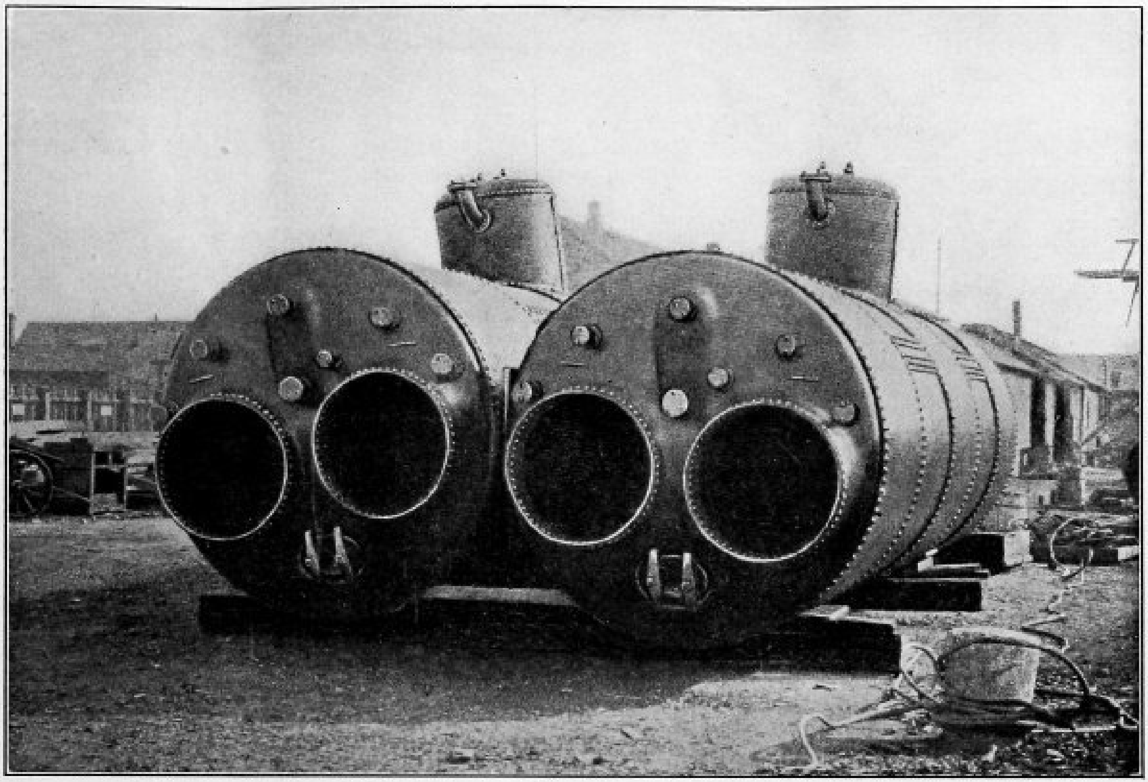
Patent and other furnaces—

$$C' \times \frac{t - 2}{D}$$

For measurements of D see page 47.

TABLE OF COEFFICIENTS FOR STEEL OF 26 TONS AND MORE.	C'.
Corrugated flue, various types	1,259
Purves's ribbed flue	1,160
Farnley's spirally corrugated flue	912
Holmes's flue	945

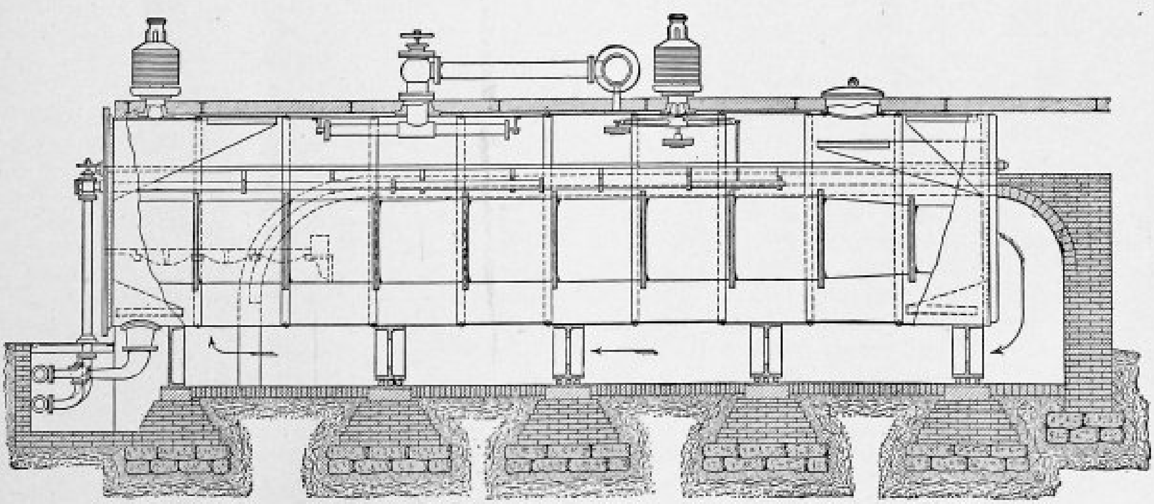
(*To be continued.*)



LANCASHIRE BOILERS OF THE TYPE USUALLY USED IN ENGLISH MILLS AND WORKS.

use in England is subjected to very great differences of temperature whilst in use, consequently the boiler must be sufficiently flexible to allow of unequal expansion without distressing any of the plates or rivets. For instance, the flues always expand more than the main body of the boiler, and hence they push out the end plates. This action is resisted by the gusset stays connecting the end plates to the main shell, and in particular the toe rivets in the angle-irons used for holding the stays to the end plates are severely stressed. If the end plates and gusset stays are made too strong, the "breathing" of the end plates is more nearly restricted to the area between the flues and the stays, so that the bending at the toes of the stays is much more severe and is liable to lead to corrosion and to leaky rivets. It is the boiler makers' art, for in this particular, boiler making can scarcely be considered a science, to know the happy mean between strength and flexibility. It is because the water-tube boiler can usually be made both amply strong and flexible that it possesses a certain advantage over its competitor, the Lancashire boiler, when high pressures are required. Boiler makers have, however, in England, steadily improved the Lancashire boiler, so that in spite of the drawbacks, which have been described, this type still holds the field for factories, works and general stationary steam engine work throughout Great Britain.

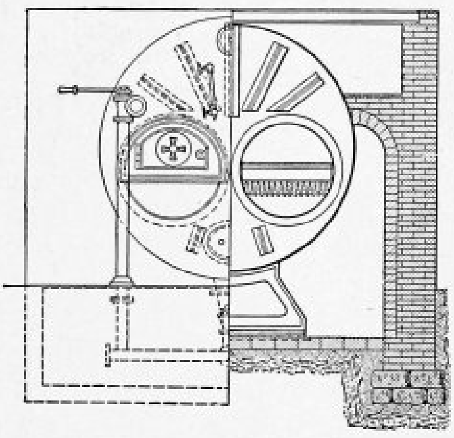
All rivet holes are now drilled accurately in position, so that each part is properly placed relatively to its neighbors, and none is called upon to bear more than its fair share of the stresses carried by the boiler. It is hardly too much to say that the high pressures to which Lancashire boilers are now subjected would not be possible with punched holes for the



SECTION OF LANCASHIRE BOILER, SHOWING SETTING AND FITTINGS.

rivets. The corrugated flue is another device of English boiler makers for giving the boiler flexibility, and one which is in fairly common use. Another feature which is coming into prominence in England is the use of dished ends without gusset stays. The end plates of the boiler are pressed to a cambered or spherical shape, the radius of the sphere being usually about equal to the diameter of the boiler. Even without the flues, which when cold act as stays, such a dished end is self-supporting, and hence the gusset stays can be abolished. Experience in England with the dished ends is as yet somewhat limited, consequently it is as yet too soon to assert that they are an unqualified success. They appear, however, to have given no serious trouble so far, and they undoubtedly simplify the construction of the boiler.

In the very numerous large factories of Lancashire and Yorkshire the conditions are specially suited to boilers of the Lancashire type. In the first place, the periods of working are quite regular and are always known beforehand. The result is that it is never necessary to put the boiler under steam from the cold or the semi-cold condition, without allowing a



END VIEW—LANCASHIRE BOILER.

sufficient time for it to attain an approximately even temperature throughout. One of the principal claims of the water-tube boiler is that it can raise steam in a very short time from the cold condition without unduly stressing the tubes and the joints, but in practically all English factories such a qualification counts for very little. On the other hand, the water-tube boiler requires more constant attention than the Lancashire boiler if fluctuations in the steam pressure are to be avoided. In some situations the water-tube boiler possesses undoubted advantages, because it occupies relatively little floor space, but where there are only two or three boilers the saving in space is not very considerable, and is not often of any great consequence except in the remodeling or extension of old factories.

The water-tube boiler has, in the opinion of English engineers, several defects; it is more expensive than the older "Lancashire" type; when there are only two or three boilers the radiation from the brickwork setting is excessive, and it is at a disadvantage when the feed water is dirty or impure. The tubes naturally lead to accumulations of deposit, which besides necessitating frequent cleaning are liable to cause overheating or wastage. Surface condensers are seldom used in English factories, so that the boiler feed water is of the same quality as the condensing water. Another point against the water-tube boiler is its comparative complexity of construction.

With the increase in boiler pressures have come improvements in material as well as design. It is usual to make all high-pressure fittings, such as testing blocks, of cast or forged steel instead of cast iron. Similarly, the steam pipes are made of mild steel. Many English engineers consider the superheater a part of the boiler, and improvements made in it during the last few years have made it a very common accessory of the factory and works boiler. To-day there are few objections, unless of a commercial character, which can be made against its use. It is usually placed in the down-take at the back of the boiler, and although in a few instances separate superheaters with their own furnaces have been fitted, these are not to be recommended on the ground either of economy or of reliability.

Rules for the Operation of Steam Boilers.

The following rules are prescribed by the department of steam boiler inspection and insurance of the Ocean Accident & Guarantee Corporation, Ltd., 350 Broadway, New York, for the management of all steam boilers insured by their company.

PRELIMINARY PRECAUTIONS.

See that water-level has not fallen; examine the joints and seams to detect leakage, and the furnaces for evidence of bulging.

Blow through the water gages; open the blow-off cock to remove any sediment; try the safety valve to insure its free action; raise the dampers to clear the flues of explosive gases; and stir up the fire, heating the boiler and setting slowly.

GENERAL OPERATION.

See that a proper water-level is maintained. Keep the water-gage glasses clean, and the passages clear by trying the gages frequently. (Lack of proper attention to water gages leads to more accidents than any other cause.)

Maintain a fire of even thickness, free from holes and clear of ashes and clinkers. (The proper thickness of fire increases with the hardness and size of coal, and with the strength of draft.) Regulate the fire, draft and feed to meet the demands for steam, keeping the water-level constant to avoid priming or burning of the plates. Ash pits are to be kept clear to avoid burning the grate bars and to prevent loss of draft and efficiency.

Never attempt to stop a leak or tighten a joint when boiler is under high pressure. Never cut in a boiler with a battery until its pressure is equal that of the battery.

Before banking fires run the water to the proper level, which note, and see that the steam-pipe drains are open and in working order.

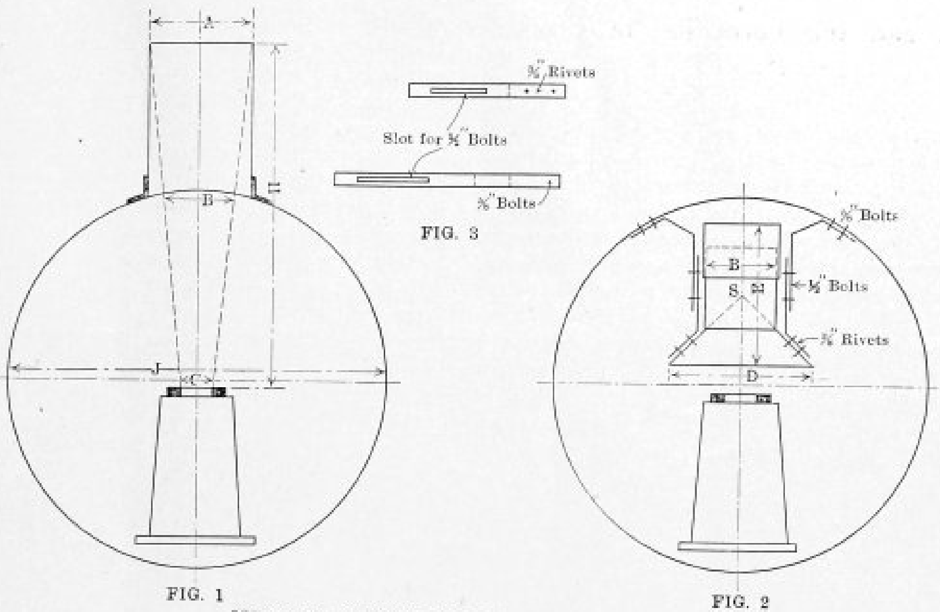
ECONOMY.

Keep the boiler clean internally and externally and thoroughly examine the plates and seams at frequent intervals, especially those in contact with the setting or exposed to the direct action of the fire.

Always raise steam slowly and never light the fire until water shows in gage glasses. Keep the furnace walls in good condition and well pointed up. Allow the boiler and brickwork to cool before emptying the boiler. Prevent oil and greasy matter from entering the boiler, as they lead to serious inefficiency and to dangerous heating of plates.

EMERGENCY.

In case of low water or evidence of distress, draw the fire at once, unless very heavy, or unless the plate or tubes appear to be red hot, in which case smother the fire with dirt or wet ashes, leaving the fire doors open and ash pit closed. Warn every person away from the boiler. If the engine or feed-pump or injector are operating do not stop them, but if not running do not start them. Do not attempt to blow off steam until the fire is out and the plates are cool, and never blow off rapidly or under high pressure.



DETAILS OF PETTICOAT PIPE FOR LOCOMOTIVE BOILER.

Layout of a Petticoat Pipe.

BY W. E. O'CONNOR.

Sometimes the roundhouse boiler maker is called upon to make and hang a petticoat pipe for some particular locomotive which does not steam well. In the absence of a blue print or other information the accompanying sketches, together with the explanation given herewith, show a very simple method of doing this work. First, open the front door of the smoke-box, and with a tape line measure the distance marked *H* in Fig. 1, also measure the diameter of the smoke-box *J*, of the stack *A*, and of the exhaust nozzle marked *C*. Make a rough sketch of the front end of the boiler, jotting down in their proper places these dimensions as they are taken. Afterwards, on a sheet or table, draw a full-sized diagram of Fig. 1.

On the full-sized diagram draw the dotted lines shown in Fig. 1 from the top of the exhaust nozzle to the top of the stack. Then the distance *B* between these lines at the base of the stack is the proper diameter for the straight portion of the pipe.

In order that the lines and letters may be more clearly seen, Fig. 2 has been drawn. This may be omitted in practice. Make the diameter *B*, Fig. 2. equal to *B*, Fig. 1. Multiplying the diameter *B* by 1.6 will give then the diameter at the flared end of the pipe *D*. The angle of slope for this flared portion should be about 45 degrees. Note that the flare line, Fig. 2, has been extended to *S*. The length of this line is needed, as it is the radius which must be used for laying out the flared end. The length of the pipe over all, marked *E* in Fig. 2, should be about 10 inches less than the distance from the top of the exhaust nozzle to the top of the smoke-box. The straight section of the pipe should be made with an adjustable sleeve to regulate the top draft.

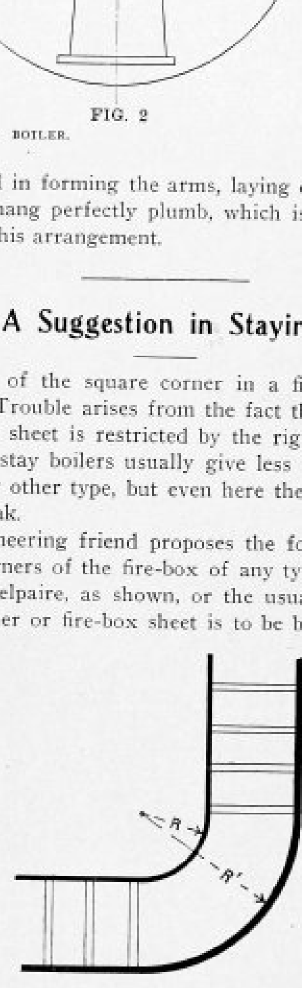
The petticoat pipe is held in place by means of two sets of bars, shown in detail in Fig. 3. These arms or supports are usually made of common wrought iron bars ½ by 2½ inches, slotted where they are joined together to take two ½-inch bolts. The smaller of these bars, two of which should be made from the pattern, are riveted to the flared end of the pipe on opposite sides with ⅜-inch rivets. The larger bars, after being bent as shown in Fig. 2, are bolted to the smoke-box shell with ⅝-inch bolts. Joining the bars together by means of the ½-inch bolts in the slots gives a means for adjusting the height of the petticoat pipe and regulating the bottom draft.

If care is used in forming the arms, laying out the holes, etc., the pipe will hang perfectly plumb, which is the essential requirement of this arrangement.

A Suggestion in Staying.

The staying of the square corner in a fire-box is not an easy matter. Trouble arises from the fact that the expansion of the fire-box sheet is restricted by the rigidity of the staybolts. Radial stay boilers usually give less trouble from this cause than any other type, but even here the corner stays are very apt to leak.

An old engineering friend proposes the following plan for staying the corners of the fire-box of any type of locomotive, whether the Belpaire, as shown, or the usual wagon-top variety. The inner or fire-box sheet is to be bent at such a radius at the corner that it will act as a section of a tube in resisting the collapsing pressure. If the metal is of such thickness that a 16-inch tube will safely resist an external pressure equal to that carried by the boiler, make the radius of the bend in the corner of the sheet 8 inches. Do not stay this curved portion in any way, since it is in the form of a tube and is capable of resisting the pressure, but extend the staying up to the point where the sheet begins to curve so as to give it ample support. This would give freedom to both the fire-box and outside sheets for expansion and contraction and should prevent some of the stay-bolt trouble, which is all too prevalent in the locomotive type of boiler.



STAYING OF FIRE-BOX CORNER.

Heat Stresses and the Formation of Cracks.*

BY CARL SULZER.

The question of the formation of cracks in iron and steel by heat stresses has been widely discussed, especially in the case of steam boiler construction. There is frequently doubt concerning the nature of the origin and the action of such stresses and concerning the true reason for the formation of the cracks. Lacking any other satisfactory explanation, one is easily inclined to ascribe the cause of such occurrences either to the material and its chemical composition or to the design of the boiler, or perhaps to its construction. Without doubt one or the other of these reasons enters into a great many cases in a greater or less degree, but it is also certain that cracks have formed where no known reason will suffice for an explanation, where material has failed, which fulfills all specifications, where the design of the boiler is above criticism and where its construction has been proved excellent.

The object of this article is to describe one such case which offers a striking example of the formation of cracks by heat stresses, and for this reason it is necessary to try to explain more fully the action of such stresses. For this purpose a

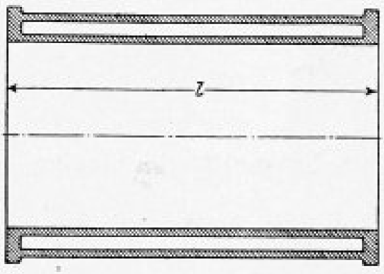


FIG. 1.—DOUBLE-WALLED CAST-IRON CYLINDER.

well-known case of crack formation as it occurs in cast iron might be briefly mentioned.

Let us consider the conditions during the casting of a double-walled cylinder, such as is shown in Fig. 1. It frequently happens that while the casting is cooling, the outer part of the mold is destroyed and the outer wall of the casting left partially uncovered, while the inner core has not been removed. The outer wall is thus cooled much more quickly than the inner one. This cooling of the outer wall causes a certain decrease in the length *l*. Since the inner wall is still in a moldable condition it offers no satisfactory resistance to the premature shortening of the length. On account of its connection at both ends with the outer wall it is forced, during the remaining time that the metal is contracting, to withstand a compressive stress which may exceed the elastic limit of the material. After the temperature of the outer wall approaches that of the atmosphere, the wall gradually forms a rigid frame, within which the inner wall, which is still hot, must cool and contract. Therefore, longitudinal stresses are set up in the latter, which, under certain conditions, may cause a fracture or circumferential cracks in the inner cylinder. Every foundryman is well acquainted with this typical crack.

The formation of the cracks begins as soon as the linear contraction within fixed points is equal to, or greater, than the ductility of the metal. The linear expansion of cast iron, due to a difference of temperature of 180 degrees F., is usually assumed to be .001 of its length. On the other hand, the breaking elongation, assuming a modulus of elasticity of 14,220,000 pounds (1,000,000 kilograms), and a mean tensile strength of about 21,300 pounds per square inch (1,500 kilograms per square centimeter), and also assuming that the elongation is proportional up to the breaking point, is about .0015 of the length of the bar. Therefore, it is evident that in the case of cast iron, a fracture will occur with a decrease of temperature of about 270 degrees F.

To prove the accuracy of the foregoing statement, the following experiment may be performed. Heat a bar of cast iron, preferably in an oil bath, to about 360 degrees F. and place it in a rigid frame, with its ends fixed in position and entirely free from stress. The bar will break after it has cooled off so that its temperature has dropped from about 360 to about 90 degrees. To avoid these harmful stresses, especially in large-sized steam cylinders, it is customary to construct the

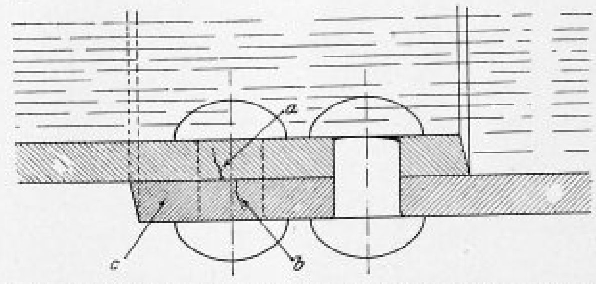


FIG. 2.—CROSS SECTION OF GIRTH JOINT, SHOWING POSITION OF CRACKS.

outer shell and the inner working cylinder separately and afterwards join them together by shrinking. Since the working cylinder is in contact with steam on both sides, it rises to a higher temperature than the outer shell, and so its connection to the outer shell must be such that it is free to expand in a longitudinal direction. In cases where this is not done, where the connection is rigid at both ends, cracks are formed, due to the repeated thrusts of the inner cylinder. Also inaccurate measurements in allowing for the shrinking operation are liable to cause the addition of longitudinal cracks in the outside shell.

While cracks in cast iron, due to the conditions just stated, can usually be quickly seen, this is not the case with the tougher mild steel. There such cracks are only formed gradually, and frequently repeated action of these destructive stresses is necessary until finally the flexible material gives way. A typical case of this kind is described below.

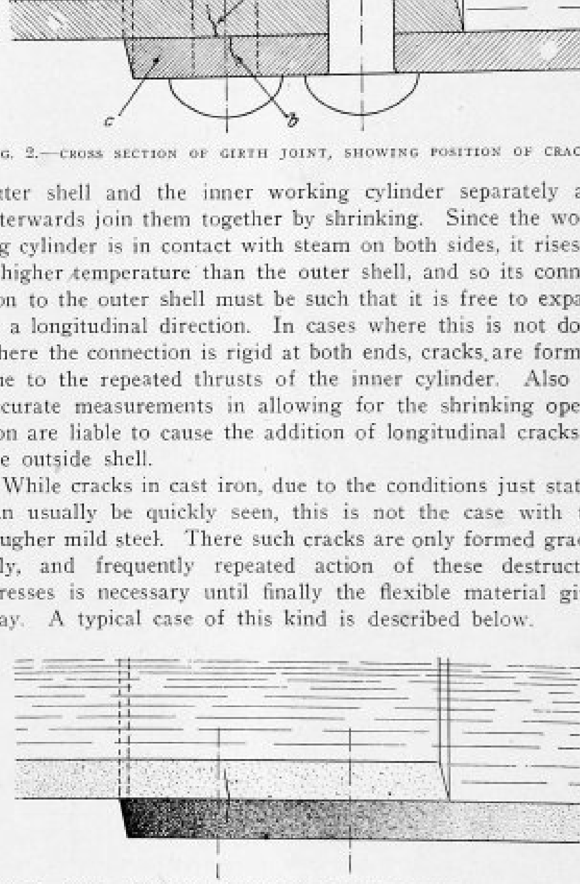


FIG. 3.—CROSS SECTION OF GIRTH JOINT, SHOWING DISTRIBUTION OF HEAT IN PLATES.

In this case the failure was in a fire-tube boiler of the following dimensions:

Heating surface, 774 square feet.

Grate area, 25.82 square feet.

Working pressure, 103 pounds per square inch.

Test pressure, 176.4 pounds per square inch.

Diameter of boiler, 78¾ inches.

Length of boiler, 23 feet 6 inches.

Thickness of plate, .512 inch.

Number of courses, five.

Longitudinal seams fitted with double riveted, double buttstraps.

Girth seams double riveted.

The boiler was built in 1899 by the Sulzer Brothers, at Winterthur, Germany. The material for the boiler was Siemens-Martin mild steel of fire-box quality. The best wrought

* "Zeitschrift des Vereines Deutscher Ingenieure," July, 1907.

iron was used for the rivets. Tests of the boiler steel made at the rolling mill showed, as a result of five tests, a mean tensile strength of 52,510 pounds per square inch, and an average elongation of 30.1 percent. Minimum results given by any of these tests showed a tensile strength of 51,800 pounds per square inch, and an elongation of 31 percent, while the maximum results were as high as 53,650 pounds per square inch for tensile strength, and for elongation 28.5 percent. Specimens of the material afterwards tested at Zurich gave a mean tensile strength of 48.790 pounds per square inch, and an average elongation of 30.9 percent. The elastic limit determined

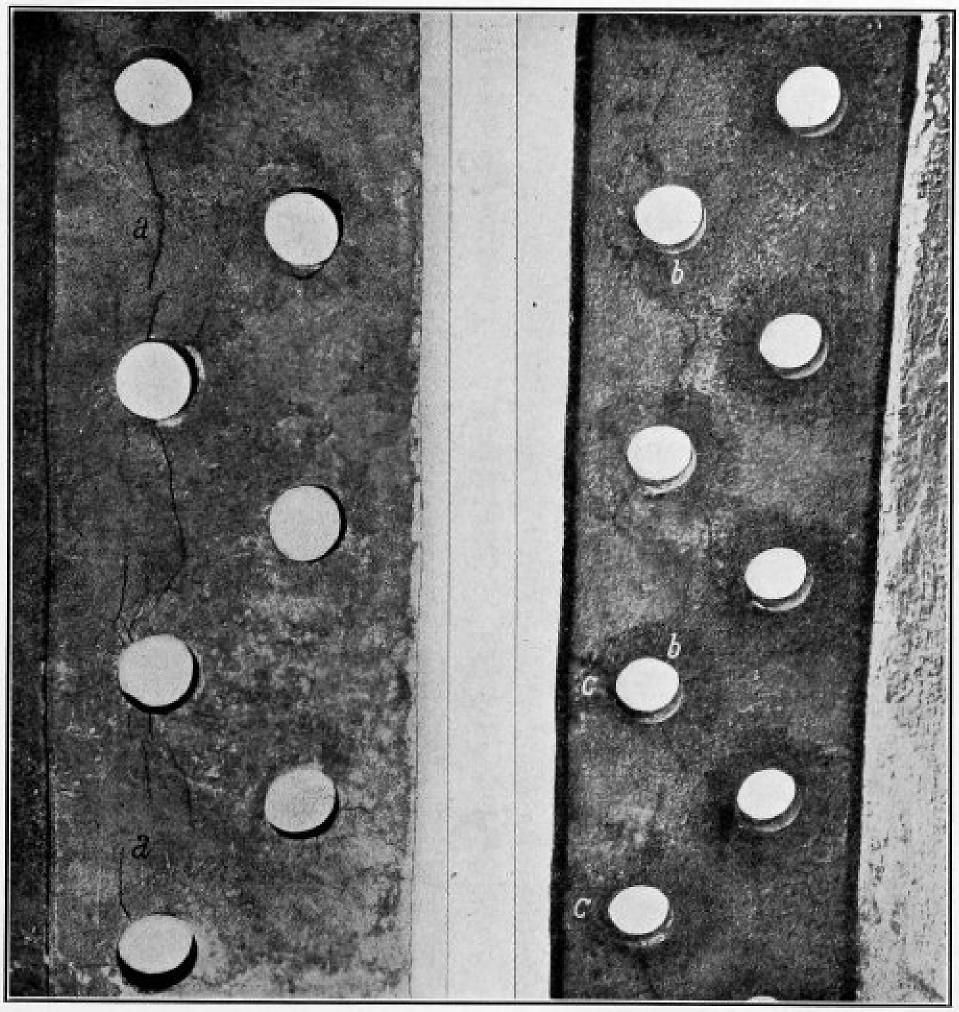


FIG. 4.—PHOTOGRAPHS SHOWING NATURE OF CRACKS DEVELOPED IN THE INNER AND OUTER PLATES OF A DOUBLE RIVETED GIRTH SEAM.

at Zurich was 36,130 pounds per square inch, and contraction of area 69 percent. These tests showed that the material was of excellent quality.

Chemical tests of the samples of plate made at Zurich showed the following results:

	Percent.
Carbon	.048
Silicon	.016
Manganese	.289
Sulphur	.04
Phosphorus	.016

The carbon and manganese are therefore normal, ensuring a steel of soft quality, while the proportion of sulphur and phosphorus is small.

The boiler, and especially its shell, was constructed with the greatest care, the manufacturers being supplied with all the best appliances for building this type of boiler. The shell plates were bent cold, and by means of a bending machine of special construction it was possible to bend the plates clear to the edge. So it was not necessary to shape this part of the plate afterwards by hand. The circumference of the courses was obtained by means of steel measuring tapes, so that the inner and outer courses fitted into place without subsequent adjustment. Also the rivet holes were drilled in place so that the holes matched exactly, and after the holes were drilled the plates were taken apart again and the burrs removed. By the use of double butt-strap seams for the longitudinal joints, local heating of the plates was avoided. The riveting was done with a hydraulic machine, so that the pressure on each rivet could be varied by changing the load on the accumulator according to the size of the rivet. The riveting machine was also equipped with a hydraulic plate closing-device of approved make. The calking, wherever the thickness of the plate would permit, was done with pneumatic tools. In fact, the greatest imaginable care was taken in the construction, and the builders claim that the quality of the work was far better than that obtained in many shops where the facilities are frequently inadequate.

The boiler was placed in service in the beginning of January, 1900. As far as can be ascertained at the present time, a number of cracks appeared during the year 1905 in the rear girth seam of the second course, which were calked. Deeper cracks, especially in the second rear girth seam, appeared in

January, 1906, and also in February, 1907. These were repaired by calking. In April, 1907, these cracks opened up again, and became so large that calking would no longer suffice. Whereupon the builders were notified. A closer examination showed that cracks had formed in other girth seams, both in the inner and outer plates, making a patch necessary on the boiler shell. The nature of the cracks, their location and their extent showed that the boiler had been submitted to a higher temperature than was customary.

Further investigation concerning the management showed that the boiler had been forced beyond its normal capacity for a long time. This was made possible from the fact that a chimney had been built which was larger than necessary to allow for a possible increase of boiler capacity. It was also

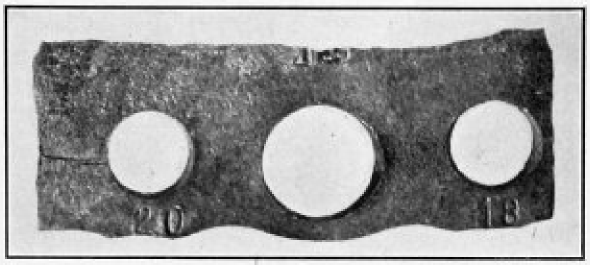


FIG. 5.—THE TAPERED PIN-TEST PRODUCED NO CRACKS, ALTHOUGH THE HOLE WAS ENLARGED 36 PERCENT.

found that only a little time was allowed for occasional cleaning. So that the boiler was necessarily cooled off quickly and placed back in service again hurriedly. Scale appeared to have formed to no very great extent. Even in the places where it was found in the greatest quantity it was only about a tenth of an inch thick.

The evaporation obtained in service was estimated to be about twice the normal capacity of a boiler of this kind, and it is fair to assume that under these conditions the temperature of that part of the boiler shell which was directly exposed to the flames must have been extraordinarily high in proportion to what it would be under normal conditions.

Fig. 2 shows a cross-section through the girth seam. The rivet spacing in the circumferential direction is 3.34 inches, the rivets in the two rows being staggered. Three different types of cracks can be distinguished in the seam as follows: The circumferential crack *a* in the inner course, extending from

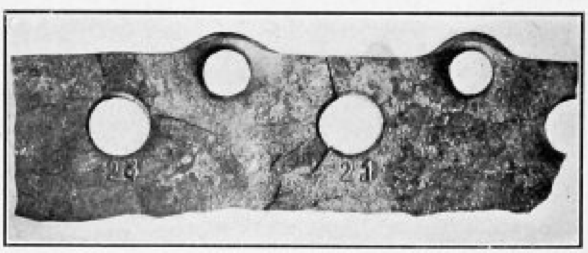


FIG. 6.—HOLES PUNCHED AT THE EDGE OF THE PLATE SHOWED THAT THE METAL HAD NOT BECOME BRITTLE.

the outside inward near the inner row of rivets; the circumferential crack *b* in the outer plate, extending from the inside outward and located near the outer row of rivets; the longitudinal crank *c* in the outer plate, extending from a rivet hole in the outer row of rivets to the edge of the plate.

Fig. 4 is a photograph showing how these cracks actually appeared in the plate. The cracks *a* and *b* at no point extended entirely through the cross-section, but the crack *c* reached through the entire thickness of the plate.

Without further consideration it is clear that cracks of this kind are not due to the tension caused by the steam pressure in the boiler, since the longitudinal seams in which the stresses from this cause were considerably greater were not damaged in the least. Neither can the cracks be considered as the ordinary fire cracks, where, on account of the rapid cooling of the outer shell, the outer course of plate contracts more quickly than the inner course, setting up a tensile stress which frequently exceeds the elastic limit, so that the outer shell finally cracks. This reason does not apply here, since the cracks begin from the surface of the plates which were turned toward each other, where there was no possibility of local cooling.

The difference in temperature in the seam may be indicated graphically as shown in Fig. 3, where the highest temperature is shown by the dark shading. The heat which enters

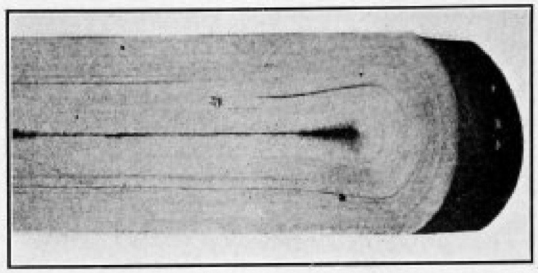


FIG. 7.—AFTER SEVEN YEARS' SERVICE THE PLATE COULD BE BENT FLAT UPON ITSELF EITHER HOT OR COLD WITHOUT SHOWING FRACTURES.

the outer plate partly flows away to the right through the plate itself and is partly transmitted to the inner plate, where, however, an important resistance is opposed to its passage. On the other hand, the temperature in the inner sheet of the seam is less than that of the outer sheet, because only a small quantity of heat flows through it and it is protected in a certain measure by the overlapping outer sheet.

In considering the action of these heat stresses, it is fitting to note the similarity with the double-wall cylinder, shown in Fig. 1. The two cylinders shown in that figure correspond to the two courses of plate which are placed one within the other, and the rigid connections at the end correspond to the two rows of rivets in the girth seam.

The outer plate of the seam is prevented in its effort to expand in a longitudinal direction, being held firmly by means of the two rows of rivets. In the circumferential direction the effort to increase the circumference or the diameter is resisted by the rivets themselves.

The force due to the expansion of the outer plate exerts a pressure in a longitudinal direction against the rivets, setting up a tension stress in the inner plate and a compressive stress in the outer plate. The stress is evidently brought on the surface of the plates which are turned toward each other. The strength of this force is evident from the fact that the rivet holes were found to be quite perceptibly oval in the direction of the length of the boiler.

It is impossible to determine the exact measure of these stresses as long as the exact difference in temperature is not known. Assuming a difference in temperature of between 360 and 720 degrees F., an average elastic limit for the material for tension and compression of about 22,000 pounds per square inch and a modulus of elasticity of 28,400,000 pounds, the expansion will amount to .00075 of the length. The sum of the expansion and contraction (.0015 of the length) is equal to the linear expansion due to the difference in temperature. Since the coefficient of expansion of mild steel for the above mentioned difference in temperature, 180 degrees F., amounts to about .0015 of the length, therefore, when the difference of temperature reaches 180 degres F., both the plates are stressed beyond their elastic limit for either tension or compression. A higher difference in temperature causes a corresponding excess over the elastic limit, and a frequent repetition of this occurrence, without doubt, leads to the gradual formation of cracks, so that the inner sheet is placed under a tension stress, and the outer sheet under a corresponding compressive stress in a longitudinal direction.

As soon as cooling begins, the shortened outer plate will be prevented from shrinking freely by the stretched inner plate, and the stresses in the seam are reversed, which starts the cracks *b*. Thus the seam is continually undergoing a change of stress, on account of which the cracks creep deeper and deeper into the plate.

Similar conditions exist with the circumferential stresses. When the boiler is heated up, the outer plate is subjected to a compressive stress in the direction of the circumference, since the free expansion of the plate is prevented by rivets. The rivets themselves are subjected to a tensile stress, as is shown from the fact that a number of the rivet heads were found to be broken off, caused, doubtless, by the above action. When the boiler is cooled off again, the sections of plate which have been permanently shortened, due to the compressive stress when the boiler was heated, are now subject to a tensile stress which tends to cause the longitudinal cracks *c*. It does not follow that stresses in a circumferential direction are of the same intensity throughout the entire girth seam. These stresses vary in intensity from rivet space to rivet space, and this fact accounts for the formation of cracks only where the plate has been subjected to the highest temperature.

It was essential that the physical properties of the material in the vicinity of the cracks should be tested after the seven years service and compared with the original properties, as shown by the tests which were made of the plate when the boiler was built. For this purpose specimens of both the inner and outer shell plates, cut both parallel and perpendicular to the girth seam, were tested at Zurich, giving the following results:

Properties.	Parallel.	Perpendicular.
Tensile strength.......	48,100	47,100
Elastic limit...........	29,720	34,600
Contraction of area....	66.0%	61.0%
Elongation	27.2%	30.0%

Specimens of the fractures showed the material to be finely fibrous.

A comparison of the above tests with the tests made of the material when the boiler was first built shows no very important changes. The numerical differences were all well within the limit of what might be expected from the same number of tests of any material.

A tapered pin test was also made, as shown in Fig. 5, by drilling a hole between two consecutive rivet holes in the seam equal in diameter to the rivet holes. This hole was enlarged while the metal was cold by driving a tapered pin into it until the diameter had been increased 36 percent, or to 1.18 inches. The metal around the hole did not show any tendency to crack.

In view of these tests the formation of cracks can hardly be attributed to deterioration of the material, but must rather be ascribed to the differences of temperature between the overlapping plates of the double riveted girth joints.

It might be said in conclusion that a boiler of this kind should not be kept in continued service under such extraordinary strain as occurred in the foregoing case. In the excessive overloading or forcing of the boiler is to be found the main reason for the failure described above, and this case gives an opportunity for boiler inspectors to make a special point of preventing such service.

On the other hand, the question arises as to whether steel makers cannot produce boiler plate which will better withstand such an excessive strain. The foregoing facts show that a better material in the sense of being better able to resist such stresses should have a higher elastic limit or smaller modulus of elasticity. A decrease in the modulus of elasticity is equivalent to decreasing the tensile strength of a meterial which has a certain ductility or percentage elongation.

Regarding the design of the boiler, the question arises as to whether a single riveted girth seam is not better able to withstand conditions of high temperature than a double riveted seam, and this question must indeed be answered in the affirmative, provided the single riveted seam is strong enough. The amount by which one plate overlaps the other is less in this case, and, therefore, there is a smaller concentration of heat in the outside plate of the lap. Also the section of plate which is rigidly held between the two rows of rivets is dispensed with, so that various conditions which were apparently harmful in the case just cited would be removed.

Finally, calking the edge of the inner plate which lies next the water in the boiler will make a tighter joint than if the outer plate alone is calked where there is a great variation of temperature.

Corrosion of Marine Boilers.

Many and various have been the explanations offered for the phenomena of internal corrosion in marine boilers, and perhaps the present article may help to throw some light upon the subject by presenting the now generally accepted facts in brief form, and untangling some of the confusion arising from the multitude of conflicting statements and observations. Professor Vivian B. Lewes—a recognized authority on the subject of marine boiler deterioration—states that in the presence of moisture, carbonic acid and oxygen simultaneously attack iron and steel, forming a thin layer of carbonate of iron. This is a very unstable salt, which almost immediately breaks down into iron oxide and ferric hydrate, liberating the carbonic acid, which, with a further supply of atmospheric oxygen, continues the process of corrosion or rusting. This process is further hastened by a certain degree of electrolytic activity between the iron and the electronegative hydrated iron oxide. Inasmuch as the layer of oxide or, as we commonly know it, rust, is highly porous, the action progresses without interruption as long as the conditions are favorable. The above general conditions obtain when any iron or steel is exposed to the action of oxygen, carbonic acid and moisture.

Internal corrosion is due chiefly to the presence in the feed water of some oxidizing agent such as air, carbonic acid gas, free acids or dissolved salts which have the property of eating iron and steel. Often the internal corrosion is the result of the presence of free fatty acids liberated by the decomposition of greases or oils, containing animal or vegetable fats, or oils introduced by lubrication and brought into circulation by the surface condensers now in general use. The rational remedy for this effect is to use no lubricants for steam-swept surfaces except pure mineral oils, which cannot decompose into acids.

Perhaps the most common cause of internal corrosion is the dissociation of magnesium chloride (of which common sea water contains about 245 grains to the gallon) into hydrochloric acid and magnesia. The acid attacks the iron with great rapidity, forming a chloride of iron, which, as soon as formed, is dissociated in its turn by the free magnesia, producing oxide of iron (plain rust, black or red) and hiding its own action by reverting to chloride of magnesium—the salt which started the trouble. It appears, therefore, that no hope may be found for this trouble in the exhaustion of the injurious reagent by the formation of insoluble salts, but that on the contrary the corrosion must continue indefinitely, unless specific means are employed to neutralize the acid elements or link them with other mineral bases for which they have a stronger affinity than for iron. If, therefore, carbonate of lime is introduced into a boiler, its carbonic acid will unite with the magnesium base of magnesium chloride, forming the highly insoluble magnesium carbonate, while the hydrochloric acid of magnesium chloride combines with the lime base and forms highly stable and perfectly harmless chloride of lime. It is perhaps not amiss to add for those readers who are not familiar with chemistry that the chloride of lime above referred to is not the "chloride of lime" of general household use, the latter containing an excess of chlorine gas by virtue of which it is useful as a disinfectant.

Electrolysis is a third form of internal boiler corrosion. An electric battery might be made up of almost any two elements or metals we could separate in an acid or alkaline bath of electrolyte. Theoretically such is certainly the case, and the amount and potential of the current obtainable would vary with each different combination of metals, some elements being strongly "electro-positive" and some strongly "electro-negative." The commercial battery, with its zinc and carbon elements and its sal ammoniac electrolyte, gives a high output for a low first cost and maintenance, and as such has established its usefulness. With its brass and copper fittings and connections, steel shell and tubes, and slightly acid or slightly alkaline water for electrolyte, a marine boiler may be regarded as a great electric cell, the iron and steel forming the negative electrodes, and the brass and iron the positive. The degree of electric activity—the output, as it were—depends chiefly upon the strength of acidity or alkalinity in the water. For every ampere of current thus developed, a fixed amount of the positive electrode—the iron —is eaten away, just as the zinc sticks are consumed in a common electric bell battery. How far the corrosive effects of magnesium chloride and the carbonic acid-oxygen combination contribute to hasten electrolysis, and how far electrolytic action promotes "rusting," have never been and probably never will be determined. Undoubtedly there are complex inter-relations and reactions of which we realize little, which, if better understood, might help to explain the extraordinary individual phenomena of pitting, grooving, honeycombing and other distinct forms of corrosion, but, in the present state of our knowledge, we can only classify these

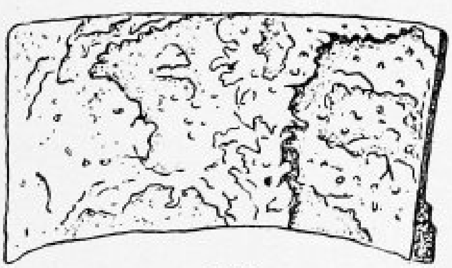


FIG. 1.

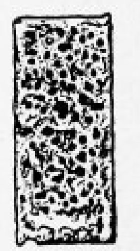


FIG. 2.

as various manifestations of the same general causes, producing different results from reasons unknown. Figure 1 is a typical case of electrolytic corrosion of a plate cut from an old main discharge pipe on a P. & O. steamer.

"Cold iron" corrosion, so called, is a familiar cause of deterioration in laid-up boilers. The remedy for this is to remove any one of the three essential accompaniments of rust, carbonic acid, oxygen or moisture. The boiler may be emptied and thoroughly dried, or may be filled up completely and low fires maintained long enough to expel all air from the water, after which all connections should be closed tightly. It is *partial* filling that is responsible for cold iron corrosion.

One is hardly justified in explaining at length the ultimate effects of corrosion of plates, tubes, stays, braces, furnaces and pipes. If corrosion has advanced far enough to weaken any part, the possible damage is limited only by the complete destruction of the vessel by explosion and the death of all on board. The most terrible phase of the subject is that all too often corrosion proceeds to the danger point in out-of-the-way corners, unseen and undetected by even the most vigilant inspection. With the ever-increasing pressures now carried in marine boilers, the necessity, always great, for adopting every possible measure to guard against corrosion is doubly urgent.

"Grooving" is a peculiar form of boiler corrosion, usually occurring near seams or at bends and knuckles. The plate becomes deeply grooved or scored, probably as a result of surface cracks, undue calking of the seams, of expansion and contraction strains, all exaggerated by acid corrosion.

A form of corrosion know as "honeycombing" is illustrated by Fig. 2—part of a plate cut from an exploded boiler. The plate was originally ½ inch thick, but was corroded to a depth of ⅜ inch, the holes appearing as if drilled.

Pitting, unlike general corrosion, is marked by sharply defined edges, resulting in holes and patches of from ¼ inch to 6 inches or more in diameter, the depth of the pit varying

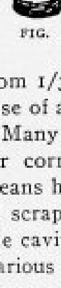


FIG. 3.

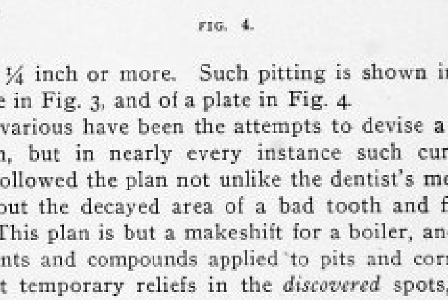


FIG. 4.

from 1/32 to ¼ inch or more. Such pitting is shown in the case of a tube in Fig. 3, and of a plate in Fig. 4.

Many and various have been the attempts to devise a cure for corrosion, but in nearly every instance such curative means have followed the plan not unlike the dentist's method of scraping out the decayed area of a bad tooth and filling the cavity. This plan is but a makeshift for a boiler, and the various cements and compounds applied to pits and corroded areas are but temporary reliefs in the *discovered* spots, and afford absolutely no protection against corrosion in other places. Neutralizing the acidity of the feed water will help considerably, but it has too often happened that the chemicals used to this end, and particularly the nostrums sold by boiler compound makers as removers of scale and grease, have wrought a havoc of their own on the plates and tubes far worse than the natural enemies they sought to repel. Zinc in slabs is extensively used in the effort to divert the electrolytic action from the iron to the more electro-positive zinc, and while much good has been accomplished by this method, it is but an incomplete remedy and a very expensive one.

The only complete remedy for corrosion is to coat the interior of the boiler with a strongly adhesive, elastic, continuous layer of non-corrodible material. This must be very thin so as not to interfere with the transmission of heat, and of high conductivity, and it should be *metallic* in nature in order to become part and parcel of the surface of the iron it is supposed to protect. This conclusion is the result of observation of successful results of a boiler compound in which mercurial salts enter into composition, the action of which, when subjected to high heat in a boiler under steam, is to deposit a dark lustrous enamel-like coating over the entire wetted surface of the boiler and its tubes. That the composition as introduced with the feed water contains the necessary corrective elements to neutralize acidity and precipitate the harmful elements of the feed water is to be assumed as a matter of course, leaving the amalgam coating to envelop the exposed surfaces and areas and prevent corrosion.

The only living ex-president of the United States, who has immortalized some famous phrases, not long ago said in effect that a successful political party should be one for the "enunciation of principles, not the denunciation of conditions." And so it should be in all things. It is well that we should understand causes and effects, but of greater importance even that we should understand remedies, if there be any.

GEORGE P. HUTCHINS.

Safe Loads on Staybolts.

BY GEORGE P. PEARCE.

In designing pressure tanks, boilers and vessels having flat surfaces where stay-bolts must be used, the table herewith, which has been worked out by the author and found useful in such designing, may be relied upon.

To illustrate the use of the table, suppose that a surface 18 by 30 inches is to be stayed against a pressure of 100 pounds per square inch, and that we wish to use ¾-inch stay-bolts. The question is, what shall be the spacing for these? The total area will be 540 square inches, with a pressure of 100 pounds gives 54,000 pounds to be supported. A ¾-inch bolt using United States standard thread would have ten threads to the inch, and, if we allow a breaking stress of 60,000 pounds per square inch with a factor of safety of 8, the safe stress will be 7,500 pounds. From the table, a ¾-inch bolt at 7,000 pounds will stand 2,114 pounds, and at 8,000 will stand 2,416. At 7,500 it would stand half way between this, or 2,265 pounds. To carry the 54,000 pounds will, then, require 54,000 ÷ 2,265, or practically twenty-four bolts. These should, of course, be so spaced as to divide the area into equal squares.—*The Engineer.*

TABLE FOR FINDING THE SAFE LOADS ON STAYBOLTS.

DIAM. INS.		THREADS		AREA OF		SAFE LOAD AT THE FOLLOWING STRESSES PER SQ. IN.					
FRAC.	DEC.	U.S.	SHARP V.	BOLT	ROOT OF THREAD	4,000 LBS.	5,000 LBS.	6,000 LBS.	7,000 LBS.	8,000 LBS.	9,000 LBS.
5-8	0.625	11	—	0.307	0.202	808	1,010	1,212	1,414	1,616	1,818
5-8	0.625	—	10	0.307	0.160	640	800	960	1,120	1,280	1,440
5-8	0.625	—	12	0.307	0.181	724	905	1,086	1,267	1,448	1,629
3-4	0.75	10	—	0.442	0.302	1,208	1,510	1,812	2,114	2,416	2,718
3-4	0.75	—	10	0.442	0.261	1,044	1,305	1,566	1,827	2,088	2,349
3-4	0.75	—	12	0.442	0.288	1,152	1,440	1,728	2,016	2,304	2,592
7-8	0.875	9	—	0.601	0.420	1,680	2,100	2,520	2,940	3,360	3780
7-8	0.875	—	10	0.601	0.387	1,548	1,935	2,322	2,709	3,096	3483
7-8	0.875	—	12	0.601	0.419	1,676	2,095	2,514	2,933	3,352	3,771
1	1	8	—	0.785	0.550	2,200	2,750	3,300	3,850	4,400	4,950
1	1	—	10	0.785	0.537	2,148	2,685	3,222	3,759	4,296	4,833
1	1	—	12	0.785	0.575	2,300	2,875	3,450	4,025	4,600	5,175
1 1-8	1.125	7	—	0.994	0.694	2,776	3,470	4,164	4,858	5,552	6,246
1 1-8	1.125	—	10	0.994	0.711	2,844	3,555	4,266	4,977	5,688	6,399
1 1-8	1.125	—	12	0.994	0.755	3,020	3,775	4,530	5,285	6,040	6,795
1 1-4	1.25	7	—	1.227	0.893	3,572	4,465	5,358	6,251	7,144	8,037
1 1-4	1.25	—	10	1.227	0.911	3,644	4,555	5,466	6,377	7,288	8,199
1 1-4	1.25	—	12	1.227	0.960	3,840	4,800	5,760	6,720	7,680	8,640
1 3-8	1.375	6	—	1.485	1.057	4,228	5,285	6,342	7,399	8,456	9,513
1 3-8	1.375	—	10	1.485	1.134	4,536	5,670	6,804	7,938	9,072	10,206
1 3-8	1.375	—	12	1.485	1.189	4,756	5,945	7,134	8,323	9,512	10,701
1 1-2	1.5	6	—	1.767	1.295	5,180	6,475	7,770	9,065	10,360	11,655
1 1-2	1.5	—	10	1.767	1.383	5,532	6,915	8,298	9,681	11,064	12,447
1 1-2	1.5	—	12	1.767	1.443	5,772	7,215	8,658	10,101	11,544	12,987
1 5-8	1.625	5 1-2	—	2.074	1.515	6,060	7,575	9,090	10,605	12,120	13,635
1 5-8	1.625	—	10	2.074	1.655	6,620	8,275	9,930	11,585	13,240	14,895
1 5-8	1.625	—	12	2.074	1.722	6,888	8,610	10,332	12,054	13,776	15,498
1 3-4	1.75	5	—	2.405	1.746	6,984	8,730	10,476	12,222	13,968	15,714
1 3-4	1.75	—	10	2.405	1.953	7,812	9,765	11,718	13,671	15,624	17,577
1 3-4	1.75	—	12	2.405	2.025	8,100	10,125	12,150	14,175	16,200	18,225
1 7-8	1.875	5	—	2.761	2.051	8,204	10,255	12,306	14,357	16,408	18,459
1 7-8	1.875	—	10	2.761	2.275	9,100	11,375	13,650	15,925	18,200	20,475
1 7-8	1.875	—	12	2.761	2.352	9,408	11,760	14,112	16,464	18,816	21,168
2	2	4 1-2	—	3.142	2.302	9,208	11,510	13,812	16,114	18,416	20,718
2	2	—	10	3.142	2.621	10,484	13,105	15,726	18,347	20,968	23,589
2	2	—	12	3.142	2.704	10,816	13,520	16,224	18,928	21,632	24,336

Boiler Repairs.

It is customary when a slight crack appears in a boiler plate to repair the leak by drilling small holes at the ends of the crack in order to prevent it from spreading any further, and then calking the crack and covering it with a patch. This sort of a repair job can be easily done by any good boiler maker, but there is one point which should not be overlooked and that is as follows: It is absolutely necessary that the small holes which are drilled at the ends of the crack be located at the extreme ends of the crack and not merely near the ends. It is often difficult to tell exactly how far the crack extends, and therefore these holes are sometimes located near the end instead of at the end. In this case, continued use of the boiler will develop the crack beyond the holes and the trouble must be repaired again.

While ordinarily careful investigation may fail to locate the ends of the crack, yet there is a simple way in which this may be done which can be depended upon. First rub the plate in the vicinity of the crack with oil, then wipe the oil off and cover the plate with chalk. The oil which has penetrated the crack will then be exuded and show plainly the extent of the crack on the chalk, whereupon the holes may be located in their proper places and either a hard or soft patch may be applied, according to the position of the damaged plate.

THE FURNACE OF THE HORIZONTAL TUBULAR BOILER is exceedingly simple in construction and easy of access, and less firebrick is required to line the furnace of this type of boiler than is the case with any other type of boiler generating the same quantity of steam. It is necessary to line the furnace with firebrick from the grate bars up to the point where the lining touches the shell and from the front to or beyond the bridge wall. In some cases the back connection is also lined with firebrick; but this is hardly necessary, as a good quality of common red brick will maintain the walls sufficiently tight to prevent leakage. The fire door arches, jams and bridge-wall, however, will need to be built of firebrick, or fireclay blocks properly scraped and baked may be substituted.

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Shop Lighting.

Boiler shops which are not provided with an electric plant for power purposes seldom use electricity for lighting, for the reason that when a manufacturer finds that he must go to some outside company and pay a high rate for the electricity used, the cost appears to be excessive. The electric light is undoubtedly the most expensive form of artificial illumination which can be used for a shop or manufacturing plant. At the same time, where high-priced labor and up-to-date machinery are in use, the loss of time for both workman and machine due to poor and inefficient lighting, to say nothing of a probable reduction in the quality of the work accomplished, may very easily entail a loss which would exceed the added cost of the electricity used for lighting purposes. Making use of some figures quoted recently in "The Illuminating Engineer," we will assume that the average retail price for electric current will amount to ten cents per kilowatt-hour. Using the kilowatt-hour as one unit, a sixteen candle-power lamp can be burned 18 hours by the use of only one unit, that is, at a cost of 10 cents. This makes the cost per hour of one sixteen candle-power lamp only 55 mills.

The ordinary workman, receiving, say, 20 cents per hour, would have to lose only a trifle over a minute and a half out of an hour to represent a loss equal to the cost of one light; while a skilled workman receiving, say, 50 cents per hour, would have to lose only a little over half a minute every hour to represent a similar loss. In other words, the ordinary workman losing 13 minutes in a day of eight hours, or the skilled workman 5 minutes in the same time, would equal the cost of running the lamp for the entire working day. These figures, of course, are based on the assumption that the electric current used costs 10 cents per kilowatt-hour. As a matter of fact, electricity, when generated in large plants, can be supplied as cheaply as 2 cents per kilowatt-hour, so that the average workman would have to lose only about 2½ minutes in a working day of 8 hours, and the skilled workman only a little over a minute to represent the cost of a lamp for a day.

The fact that electric lighting, even in cases where the current must be supplied by some outside company, should, under favorable conditions of shop management, pay for itself rather than represent a loss to the manufacturer, is not the only reason, however, for the use of this form of lighting. Anyone who has worked several hours at a stretch cramped up inside a boiler in hot weather with a smoky kerosene torch would not fail to appreciate the advantage of using an electric light in place of the torch.

An English Opinion of American Boilers.

One of our English contemporaries recently made the statement that the United States has the most dangerous lot of steam boilers in existence, adding, furthermore, that this is the statement of a fact which the records of boiler explosions prove conclusively. This fact is ascribed to bad workmanship, much of which, it is claimed, is far behind what would pass as third-rate in England. In particular, it is pointed out that it is still an extensive practice with American boiler makers to punch or drill the rivet holes in boiler plates before the sheets are bent, a fact which contributes largely to the failure of riveted seams, especially when they are of the lap variety.

It cannot be denied that the number of boiler explosions in the United States is exceedingly large as compared with other countries. Neither can it be denied that it is an extensive practice with American boiler makers to punch or drill the rivet holes in boiler plates before the sheets are bent. We do not wish to make any excuses for the faults which exist in American methods of boiler construction. On the other hand, we wish to point these out and, if possible, show how they may be remedied. We are yet to be convinced, however, that poor workmanship is the main cause for this excessive number of explosions.

In general, boiler explosions may be due to the following causes: faulty material, poor design, bad workmanship, inefficient management, lack of careful inspection, and finally to carelessness and accidents. It is impossible to obtain figures showing the total number of boiler explosions which occur in the United States per year, the only information on this point being the records of boiler insurance companies. Such records are, of course, incomplete and represent only a small part of the total number of explosions which occur, and in such cases as are recorded it is not always possible to determine the exact cause of the explosion. To draw any conclusions from such incomplete statistics may perhaps seem useless, but if such conclusions are to be drawn they will hardly point to bad workmanship as the principal cause of boiler explosions. Lack of inspection and carelessness in operation are responsible for by far the greater number of these disasters.

Convention Announcement.

The annual convention of the International Master Boiler Makers' Association will be held at the Hotel Ponchartrain, Detroit, Mich., May 26, 27 and 28, 1908. The rates for the hotel will be as follows: Single room without bath, $2 and $2.50 a day; two persons in a room without bath, $3, $3.50 and $4; single room with bath, $3, $3.50, $4 and $5; two in room with bath, $5, $6, $7 and $8. The use of the convention hall and three committee rooms is to be given without charge.

Why Are Boilers Like Women?

1st.—Because we cannot get along without them.

2d.—Because one is needed in every home.

3d.—Because when properly designed they are fairly good to look upon.

4th.—Because it takes skilled hands to put them together.

5th.—Because they require a lot of attention and need a good man to take care of them.

6th.—Because they can cause a whole lot of trouble when least expected.

7th.—Because they are a man's best friend when properly cared for.

8th.—Because at times they do considerable weeping without any good cause.

9th.—Because when properly cleaned, fed and dressed, they will give good results.

10th.—Because it would be a cold world without them.

11th.—Because they are all-powerful.

12th.—Because if you misuse them they will strike back.

13th.—Because it does not take much to cause a blow up.

14th.—Because some of them are poor steamers.

15th.—Because they are all sizes, both large and small.

16th.—Because they must be stayed to perfection.

PERSONAL.

THE CANTON BOILER & ENGINEERING COMPANY, Canton, Ohio, have secured as their Eastern representative Mr. Herman Nieter. Mr. Nieter's office is at 2 Rector street, New York City.

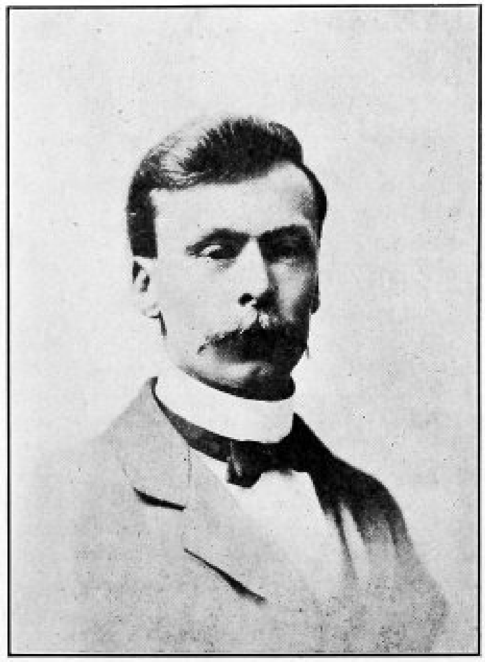
EDWIN H. FOWLE, formerly of San Francisco, Cal., has been appointed representative for the National Tube Company, the Western Tube Company and the Shelby Steel Tube Company for the Rocky Mountain district, with offices in the Majestic building, Denver, Col.

WALTER FORBES, aged 64, died recently of pneumonia at his home 1324 Woodlawn avenue, Pittsburg, Pa. He was born at Islay, Scotland, and came to this country when 18 years old. He settled first in New York, but after living there several years, moved to Pittsburg, where he made his home until his death. Mr. Forbes was a boiler maker, and his many years of service in this trade had earned for him the well-deserved reputation of a splendid mechanic. He was employed for many years by the Pittsburg Locomotive Works, and later by the American Locomotive Company. Mr. Forbes is survived by a widow, two sons and five daughters.

J. L. CRONE, formerly assistant boiler inspector at the port of New York, has been appointed to the position of United States boiler inspector, vice Theodore T. Mersereau, resigned. Mr. Crone was formerly a local inspector of boilers at Portland, Me., and was transferred to New York some time ago as an assistant. He has had long experience in the service and proved himself worthy of the promotion.

"Technical Literature," a monthly magazine of technical information for engineers, designers and constructors, published by the Technical Literature Company, 220 Broadway, New York, is henceforth to be known as "The Engineering Digest." Mr. E. Bjerregaard continues as manager of this publication.

JAMES CROMBIE, who won first prize in the Champion contest for the best essay on "How to Heat and Drive Steel Rivets" at the last convention of Master Steam Boiler Makers, served his apprenticeship with Messrs. Hall, Russell & Company, Ltd., Aberdeen, Scotland. Mr. Crombie was connected with this concern for about twelve years, when he left to enter



JAMES CROMBIE.

the employ of Messrs. James Abernethy & Company, Ltd., Ferryhill Iron Works. Later he was foreman boiler maker for the Aberdeen Steam Trawling & Fishing Company. In May, 1903, he left Aberdeen for Canada, and since then has held the position of foreman boiler maker with Sawyer & Massey, Hamilton, Ont. Mr. Crombie is the inventor of a successful device for discharging ashes on board ship, and has contributed a number of valuable articles to the technical press.

COMMUNICATION.

Why Boiler Inspectors Should be Practical Boiler Makers.

EDITOR THE BOILER MAKER:

I would state that, from my observation and experience, there is not a department in any large city or State which is more important than the Boiler Inspection Department.

This being self-evident and the importance of this matter being conceded, the burden of conducting this office in a proper and efficient manner devolves on the people who make the rules, regulations and laws for the department and who are also responsible for its financial condition.

The duties of the Department of Boiler Inspection are inspecting boilers and passing upon their safety and condemning them if they are not safe. It is obvious that this is a highly important matter, and that consequently there should be no incapable man engaged to fill these positions, and further, with good men in these positions they should have ample time to properly inspect the boilers. With these two important factors in mind, I would then like to consider, first, who shall make these inspections; second, how shall they be made.

First—Who shall inspect boilers? I note with great interest the stand that a certain inspector has taken against men qualifying for positions as boiler inspectors who are not practical and experienced boiler makers. I understand that some of the suspended men who were recently suspended by the inspector have produced letters of recommendation from certain firms, stating that they have had years of experience, but failed to say what branch of industry it was in. We could rightly ask the question: Was it in a cornfield, the political field, a carpenter shop, a blacksmith shop, a machine shop or an engine room, or where did they get their experience? None of the firms mentioned ever owned a boiler shop, to our knowledge. Some of the dismissed applicants who have secured an appointment, so far as I am able to learn, are not practical boiler makers, and I ask in the name of the American people, do you wish to risk your life and the lives of your relatives and friends in the hands of incompetent boiler inspectors, men who never, in all their lives, had a day's experience in the construction or repairing of a boiler? I should answer, no!

Who knows, better than a practical boiler maker, what a boiler is made of? Who knows, better than a practical boiler maker, how boilers are made? Who knows, better than a practical boiler maker, how much abuse they will stand? Who can tell the condition of the plates, by sound, better than a boiler maker? Who can tell, better than a boiler maker, when a boiler is in a dangerous condition? The answer is, none.

They, themselves, positively know from the experience they have had in the shop, what no living man could learn from books and what it has taken them a lifetime to learn by hard work and hard knocks. There is only one class of mechanics in the world to-day who are actually capable of inspecting steam boilers, and that class is the practical boiler maker, and he alone. The man who has built boilers, who has repaired them, who has worked in and around them under all conditions, who has acquired a knowledge of the strength of the material which boilers are made of, by actual working, bending and breaking of the plate and rivets; men who are acquainted with all the kinks of the trade, men who are familiar with the cheap methods of manufacturing; men who know good workmanship from bad; men who can tell the thickness of the plate by sound, which alone requires years of actual working of the material as the sound changes with every thickness of plates; men who have had years of experience building and repairing boilers, know exactly where to look for defects and how they should be repaired.

His ear for this work is trained like that of a piano tuner, and from working on the various thicknesses of material in the shop he is able to determine by sense of feeling and sound almost the actual thickness of the material at the different places. No one can do this who has not been trained in a boiler shop. Flues are sounded for thickness. Rivets are sounded to find out if defective or broken. Braces are sounded for weakness or defects.

In testing the strength of tubes and flues, he strikes them in such a manner with his hammer that he is able to determine their toughness for holding power. He has worked many sets of flues, and has evidently broken off many beads, which to an ordinary person, other than a practical boiler maker, would look perfectly safe and sound, but from his practical experience he is able to judge their actual holding value better than any other man who has not had years of boiler-shop experience.

I desire to have those interested know of at least one of the bad accidents which has happened through inefficient inspection. In June, 1903, a tubular boiler, which was used at the power house of the R. C. waterworks at R. C., Mich., was condemned by a practical boiler maker, who is now holding a position as boiler inspector. The boiler in question was not used by the waterworks people after its condition was reported to the authorities, and it was taken out of service. Notwithstanding the fact that the boiler had been condemned by a practical boiler maker, who had official authority to inspect boilers, a certain master mechanic, who is not a boiler maker, pronounced it O. K. and bought it (which action, we are pleased to state, is not a practice of master mechanics), and had it placed in a sawmill, where, on the very first day it was fired up, the boiler exploded and killed seven men.

This is a sample of what is going on in this great country of good laws. There should be a law punishing a man doing such things who pretends to know all about boilers; who deceives others, when in reality he knows nothing about a boiler. Man was made to mourn, says Robert Burns, but someone will have to show the boilermakers some of these days why men and their relations are made to mourn in this manner through the blundering ignorance of some would-be boiler expert. The day has come when people in authority will not tolerate the appointment of any person to such a responsible position as boiler inspector, but will insist upon all boilers being inspected by practical boilermakers.

This, then, should be impressed upon the minds of every good citizen, that none but trustworthy, competent, practical boiler makers should fill the responsible position of boiler inspectors. "What is worth doing at all is worth doing well," and if a boiler is inspected at all it should be done by men who are thorough, practical boiler makers.

Second—How should boilers be inspected? To give just a faint idea of the amount of actual work which is required for a boiler inspector to make such an inspection as is absolutely necessary for the safety of the general public, I will give the following example: We will select a horizontal tubular boiler, which is the simplest form of a boiler, and the one which is in general use at the present time. Taking for this example an average size, about 60 inches in diameter and 16 feet long, the first thing that an inspector must do is to make arrangements with owner of boiler to have said boiler ready for inspection on a certain day and hour. These arrangements are, of course, made by chief inspector or his clerk. To be ready for inspection would mean that the owner should have boiler empty and all hand and manhole plates removed and boiler cold so that inspector would not be roasted to death while making inspection. It is, of course, at the inspector's own discretion whether he inspects the inside or outside of boiler first. We will assume that he first inspects the under side or bottom of boiler. In this event he crawls into the furnace over the grate and scrutinizes that portion of the boiler carefully, and assuming there are no visible defects, he at once begins what is known as the hammer test.

He hammers every square foot of the surface of the boiler as far as he is able to reach, sounding it for laminations or other defects in the material, and carefully notes the sound as he proceeds with the inspection. He next inspects the entire bottom of the boiler by this method, crawling through soot and ashes until he reaches the extreme back end, and after a careful inspection of the back head in regard to the condition of tubes, he carefully studies the strength of bead on tubes. He then examines boiler on center line at bottom to see if it is bagged. If so it is in a dangerous condition. And why should a boiler which is bagged be in a dangerous condition? This is an easy question for a good, practical boiler maker to answer, as he has, no doubt, cut out many similar sheets and found the effects of a large bag on the riveted seams, which would show, in many cases, that the great strain that caused the boiler to bag also caused the rivets to partly shear and the metal to become thin in center of bag, thereby leaving the boiler in a dangerous condition.

He is now through with the external inspection of bottom of boiler, which (if thoroughly done with a view of safety in mind) has consumed the best part of an hour, if it is found that every part thus far examined has been found in perfect condition. But if defects are found, the time consumed would be much greater.

The next step is to go to the front manhole under the tubes, crawl in on the bottom of the boiler and make a close inspection for pitting or corrosion next to seam, and taking note of measurements of braces on flat surface of head and sounding same for defects. After this is done he inspects the blow-off and feed-pipe and the water-column connection to see if they are free from scale. This part of the inspection, in all probability, has consumed no less than one-half hour. If everything has been found satisfactory the inspector will order the lower manhole plate put in, and the water turned on in order that the lower portion may be filling. He then makes his way to top of boiler for inspection there. Here he crawls into boiler through manhole, which is usually located on top, and proceeds with his inspection. He very carefully sounds the top portion of the boiler above the tubes, and especially along the waterline if the boiler is located in a coal-mining district and the water is used from a well in its vicinity. In such localities considerable matter is found in the water, which is very destructive to boiler material along the waterline, as the impurities seem to float on top of the water and attack the material at this point (these are points gained by practical boiler makers in repairing boilers in the different localities).

He then takes the measurement of the rivets in the longitudinal seam to determine their pitch and diameter and sounds all rivets to see if they are defective or broken. If rivets are broken or defective, an expert boiler maker with his trained ear for these sounds detects them instantly. He next turns his attention to the tubes and sounds them for thickness; if he has satisfied himself they are all right, his next step is to examine braces which hold flat surface of boiler head above tubes, taking the necessary measurements of same. He sounds every brace, together with rivets in both ends, front and back head and takes note of any weakness or defects. He next turns his attention to opening in boiler where the gage cocks and water column are connected to see if they are clear or filled with scale or sediment; after this is done he gives his attention to dome and carefully inspects same, measuring up braces, sounding them for defects, and sounding parts of dome. Finishing this part of the inspection he crawls out of boiler. As soon as he gets out he orders boiler completely filled up with water and top manhole put in. The time he has spent in this part of the work would consume about 1½ hours, if done thoroughly.

This would make a total of 3 hours of faithful work.

While the boiler is being filled with water the inspector should make the necessary calculations to determine the safe working pressure. This should be done so that he can tell how much water pressure to apply to determine whether or not there are any invisible cracks or leaks; the safety valve should be removed and a plate and gasket bolted over the opening.

After pressure has been applied the safety valve should be screwed back again and the safety valve set to working pressure allowed before turning boiler to owner.

The safety valve is removed to save strain on spring while excess strain is on boiler. The time to fill such a boiler usually takes about an hour, depending upon supply pipes and method of filling same, and by the time he has applied the water test, taken note of steam gage to see if it corresponds with his test gage, and after making another inspection for leaks or invisible cracks he has consumed another half hour. This would make a total of 3½ hours, assuming that the inspector had all the necessary calculations in the form of tables so that he could ascertain the safe working pressure in a few moments. He still has his pumps to disconnect and load into his wagon to go to the next place. In my judgment, if he completes his task in 5 hours he has done well.

I may add that there is very little danger of breaking braces by water test, if you have examined them and found them sound and allowed them a factor of safety of five or six, as the water test usually applied is only 50 percent in excess of working pressure. The inspector should set safety valve before he leaves plant or turns boiler over to owner.

The State boiler inspector's office should be furnished with a complete detail drawing of every new boiler installed in the State. This would facilitate an inspection, as all necessary calculations could be made beforehand, in the inspector's office and compared with the inspector's report when turned in.

A thorough inspection is needed for the safety of the people, and the fee stated in bill on boiler inspection laws for the State of Oklahoma, $5, is not too large. The good people would not object to pay this amount for a good, thorough inspection.

I believe that the majority of boiler owners desire to know actual conditions of their boilers and would feel well satisfied to pay the sum named, if they were assured that their boilers would receive a good, thorough inspection by a good, practical boiler maker. T. J. H.

TECHNICAL PUBLICATION.

Marine Boiler Management and Construction. By C. E. Stromeyer. Size 6 by 9 inches. Pages, 404. Figures, 452. London and New York, 1907: Longmans, Green & Company. Price, 12s. net ($4.00 net).

This is the third edition of a work which was issued first in 1893. It deals entirely with the return tubular boiler, popularly known as the "Scotch" boiler, this type having stood the test of many years of operation. The main addition in this edition has been along the line of materials and better methods of working them, due to a better knowledge of their structures and elements. This includes a study of the microscopic structures of various steels, and also a study of gas analysis and its relation to the up-take and funnel.

The work is divided into eleven chapters, the last two of which summarize the boiler rules of Lloyd's Register and the Board of Trade. The other chapters cover, respectively, boiler management, steam and water, corrosion, fuels and combustion, heat transmission, strength of materials, mechanics, boiler construction and design. The numerous illustrations are all in the nature of sketches, showing the various parts and the strains to which they are subjected, and the methods of achieving definite results from given material. The subject of riveting comes up for extensive treatment under the heading of "Boiler Construction." A comprehensive index at the rear of the volume makes it easy of reference.

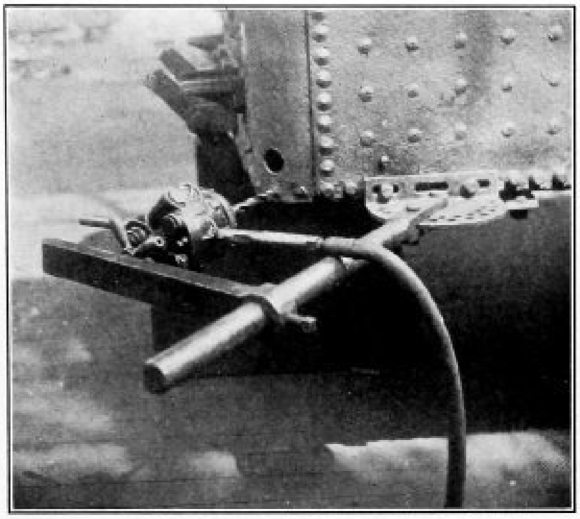
ENGINEERING SPECIALTIES.

A Handy Drill Post.

The difficulties attending the satisfactory fastening and adjustment of a drill post or "old man" for work on curved surfaces, such as boiler shells and fire-boxes, are well known to all shop mechanics. There have been many temporary makeshifts fixed up to overcome the trouble in special cases which were thrown away as soon as they had answered their purpose, and it was up to the next man to conjure up something for himself.

For correcting this state of affairs at the Hornell shops of the Erie Railroad, Mr. Thomas Kuhn, foreman boiler maker, has designed and patented a device which, while answering all the purposes of the rigid foot drill post, is also available for convenient adjustment on curved surfaces.

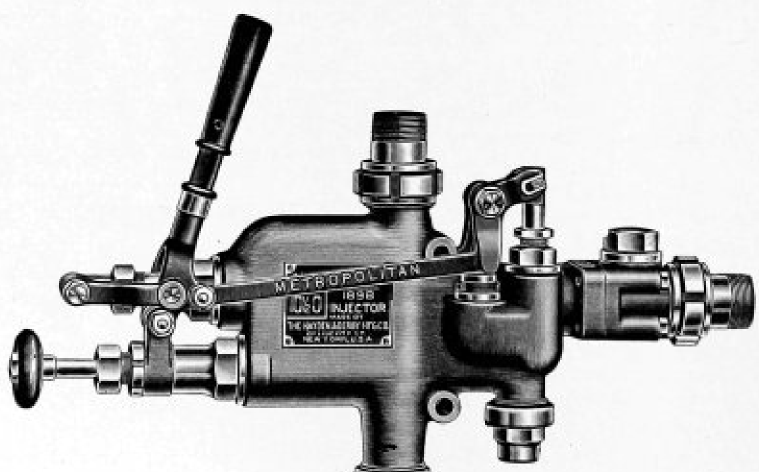
As will be seen in the illustration, the only material difference in this device from the usual drill post is in the construction and method of securing the base. The base here consists of a semi-circular piece of boiler plate ½ inch thick, flanged so as to leave a 3-inch right-angle turn and a full half circular base. In the center of this base a ¾-inch hole is drilled and 1⅜ inches from the circumference a series of equally spaced holes are also drilled. The right angle flange is provided with ¾ x 2⅝-inch slots located ⅞ inch from each end, and through these slots pass the bolts that are to secure the device to its support.



The standard is of forged soft steel drawn square 10 inches from the end, and in this square portion a slot ⅝ x 6½ inches is cut and two holes ¾ inch diameter and 3⅞ inches apart, drilled at right angles to the slot, permit pins to be dropped through the standard and base, the back pin acting as a pivot. By placing the standard at any angle with the base and dropping the forward pin into one of the holes along the circumference, any desired adjustment may be obtained.

Metropolitan Injector, Model O.

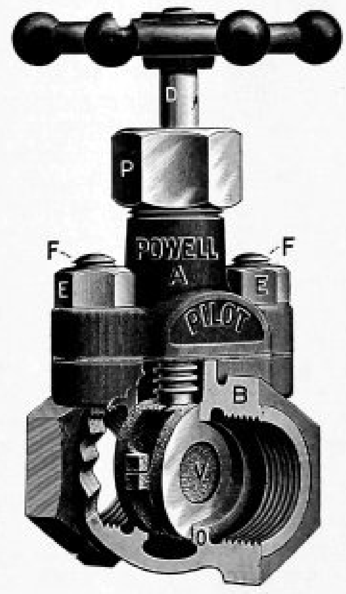
The Metropolitan "1898" injector is a double tube injector, made extra heavy throughout, which is especially recommended for high steam pressures, hot feed water and severe



conditions generally. Special attention is given in the construction to obtaining durability and simplicity so that repairs will be infrequent, but may be easily made when necessary. It is equipped with special safety devices, which make it less likely to be effected by the failure of the valves in the piping. The vertical check valve is guided top and bottom and has a large opening. The casing for this valve is independent of the main injector casing and is joined to it by flange joints, an arrangement which permits the check valve to be examined and reground at any time and also permits the injector being removed without removing the check valve from the delivery pipe. The capacity may be regulated by increasing or decreasing the amount of steam fed in the lifting apparatus. This injector is manufactured by the Hayden & Derby Manufacturing Company, 85 Liberty street, New York City.

The "Pilot" Iron Body Gate Vaive.

The "Pilot" iron body gate valve is another addition to the already long list of steam specialties manufactured by the William Powell Company, Cincinnati, Ohio. The illustration



shows a strong, compactly built valve with every detail carefully worked out. The iron body is built for service and is designed with heavy lugs on either side of the neck, carrying the stud bolts *F*. The bonnet cap *A* has corresponding lugs drilled from a template, which insures a perfect joint and constant alignment at all times, and also allows the bonnet to be replaced without unusual care after taking apart for inspection or repairs. Two semi-finished hexagon nuts *E* large enough to admit wrenching down hard, with a joint of the best packing material between the faces of bonnet and body, make an absolutely tight joint for all pressures up to 100 pounds. The brass stem *D* and bonnet are chased and cut to a true Acme thread of unusual length to allow for wear. The length of the thread keeps the stem in a true axial position at all times whether open or closed. The knobby hand-wheel gives a firm grip, even though the operator's hands may be oily. The discs are double, not a single wedge, with ball and socket back, making them adjustable. They are hung in recesses to the collar on the bottom of the stem. The discs, working in a tapering seat, expand or collapse in opening or closing, making a valve that will close down tightly without straining or opening easily, no matter what the conditions may be.

The Powell Pilot gate valve is also made all iron, that is, discs, stem and packing nut are of iron, not a particle of brass being used on its construction. This all-iron Pilot gate valve is used principally in controlling ammonia, cyanide solutions, acids and all other liquids or gases that attack brass.

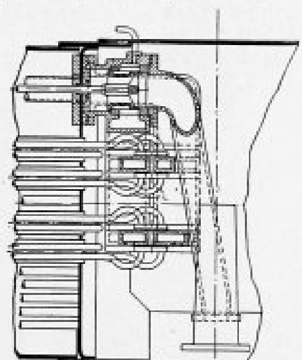
SELECTED BOILER PATENTS.

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.

869,669. SUPERHEATER. Max Toltz, of St. Paul, Minn., assignor of one-fourth to Charles Hawley, of Chicago, Ill.

Claim.—A locomotive boiler containing two pairs of horizontal rows of enlarged flues, in combination with horizontally disposed and divided saturate and superheated steam headers having their upper and lower parts relatively between the



flues of the upper and lower rows of flues respectively, suitable dry pipe and steam feed connections to said saturate and superheated steam headers respectively, and superheater elements arranged in said flues and having their ends connected to adjacent portions of respective headers. Twelve claims.

870,455. LOCOMOTIVE-BOILER. James M. McClellon, of Everett, Mass.

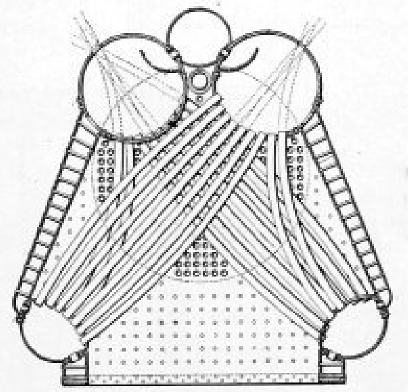
Claim.—In a locomotive boiler, a water-containing chamber and a fire-box separated by a flue-sheet, flues extending from said chamber and opening into the fire-box, a steam-generator associated with the firebox, said generator being separate from the chamber, whereby the water in the generator may be maintained at a higher temperature than that in the chamber, and means to connect the top of the chamber to the generator so that water will flow into the generator only when the chamber is filled. Seventeen claims.

871,040. LOW-WATER ALARM. William Loudon, of Seattle, Wash.

Claim.—In a device of the class described, a tubular ellipse, means arranged to form communication between the steam generator and the interior of the ellipse, means extending along the major axis of and rigidly connecting the opposite ends of the ellipse against longitudinal expansion, a signal mounted adjacent the ellipse, and a rod extending along the minor axis of the ellipse and rigidly connected at one end to the ellipse and at its opposite end to the signal to actuate the same. Five claims.

870,306. FIRE-BOX FOR LOCOMOTIVE-BOILERS. James M. McClellon, of Everett, Mass.

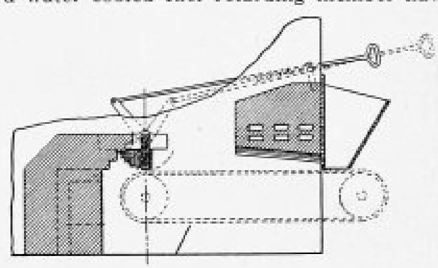
Claim.—In a boiler structure of the locomotive type, the combination with a shell having flues therethrough, of a fire-box having a water-chamber at the top and other chambers at the bottom on each side, and inclined water-tubes connecting



each lower chamber with the upper chamber on the opposite side of the fire-box, said water-tubes covering substantially the entire end of the shell, and means to cause all the hot gases generated in the fire-box to pass through the net work of water-tubes in transit to the flues. Twenty-four claims.

870,968. FUEL-RETARDING MEMBER FOR FURNACES. George L. Junge, of Pittsburg, Pa.

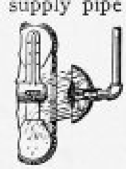
Claim.—In a furnace in which the fuel is caused to travel within the combustion chamber during combustion, a fuel support and a water cooled fuel retarding member having trun-



nions whereby said member is pivotally supported at an interval above said fuel support, one of said trunnions being hollow to form a water passage communicating with the interior of said member. Sixteen claims.

871,090. SMOKE-CONSUMING FURNACE. Frank E. Kelly, of Minneapolis, Minn., assignor of one-half to Frederick Kees, of Minneapolis.

Claim.—The combination, with a furnace and its grate, of a blast fan having a discharge opening leading into the fire box, a curved deflector arranged opposite and near the intake opening of said fan, a water supply pipe extending through said



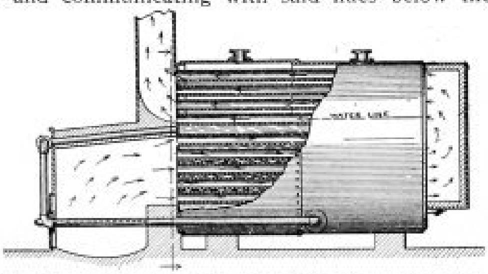
deflector and a second oppositely curved deflector arranged in front of said water pipe and against which second deflector the water is discharged and directed therefrom against the curved wall of said first named deflector and from thence delivered in a thin sheet into the path of said fan. Two claims.

872,378. HIGH-PRESSURE STEAM GENERATOR. Adolph J. Schaaf, of Pittsburg, Pa.

Claim.—A steam generator comprising a battery of lower parallel drums spaced apart and arranged in pairs, a supplemental upper drum arranged above each pair of said lower drums and spaced therefrom, pipes between said lower drums and upper drums, vertical rear and side walls spaced from said lower drums, a combustion chamber within said walls, longitudinal bridge plates between said lower drums, longitudinal bridge plates between said side walls and said lower drums, longitudinal bridge plates between each of said upper drums and its respective pair of lower drums, a smoke arch at the rear ends of the drums, and a smoke hood at the forward ends of the drums. One claim.

871,201. SUPERHEATING-BOILER. George Y. Bonus, of Chicago, Ill.

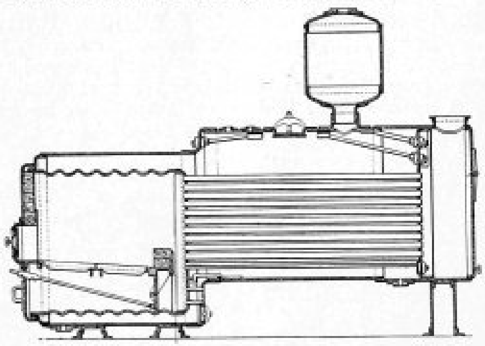
Claim.—In a boiler, a single compartment having a plurality of fire flues passing therethrough, a portion of said flues being below the water line and a portion being above the water line, a fire box located outside of said compartment at one end thereof and communicating with said flues below the water



line, a header arranged at the front end of said fire box having communication with the lower side of said compartment and a plurality of inclined parallel tubes connecting said header and said compartment a short distance below the water line serving as a lining for the fire box. Seven claims.

872,291. STEAM-BOILER. Harry Vincent Brady, of Amherst, Nova Scotia, Can.

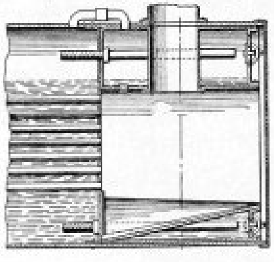
Claim.—In a steam boiler, a furnace and barrel connection having lap-joint rims projecting on its front and rear sides



respectively and offset portions integral with the respective rims. Ten claims.

872,438. BOILER. John Lindner, of Waconia, Minn.

Claim.—In a boiler of the class described, a shell, a flue sheet extending across the shell and dividing the front of the boiler from the smoke box, a separate water jacket fitted within the smoke box, and approximately annular in form in



cross section, the rear wall of the jacket fitting against the flue sheet, and circulating pipes extending through said rear wall and flue sheet. Four claims.

873,094. BOILER. William G. Ross, of Chicago, Ill., assignor of one-half to Frank Sutherland, of Chicago.

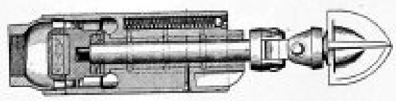
Claim.—A boiler comprising a heating chamber having vertically disposed tube sheets at opposite sides thereof, a plurality of tubes extending transversely between said sheets, and a casing fitting against one of said tube sheets and having a plurality of horizontal partitions extending toward and abutting against the tube sheet and forming a substantially watertight joint therewith, and a plurality of vertically disposed partitions connecting adjacent horizontal partitions, said partitions being arranged to form a plurality of pockets each connecting an adjacent pair of tubes, a second casing abutting against the other tube sheet and having a corresponding system of pockets, all arranged to cause water or steam to follow a tortuous path upwardly through said system of tubes. Two claims.

872,382. FURNACE STOKER. Edwin E. Slick, of Pittsburg, Pa.

Claim.—A stoker having a transverse shelf extending forwardly into a combustion chamber and terminating short of the wall opposite said shelf to form a fuel bed space beyond the shelf, and a series of independently adjustable pushers arranged to move on the entire width of said shelf and feed the fuel forwardly across the shelf and combustion chamber, and adapted to vary the amount of feed for the fuel across the width of said chamber. Five claims.

874,174. TURBINE. William S. Elliott and Frank M. Faber, of Pittsburg, Pa.

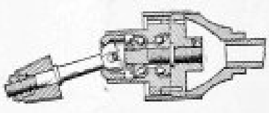
Claim.—In a turbine, a barrel or casing having inwardly projecting webs supporting a bearing, a removable bushing for said bearing, a turbine wheel having a forwardly projecting



shaft within the bushing, a stationary turbine member secured within the casing at the rear of the turbine wheel, and rear nozzle or supply chamber secured at the rear end of the casing. Twenty-four claims.

874,258. TUBE AND FLUE CLEANER. Harry S. Stormer, of Johnstown, Pa.

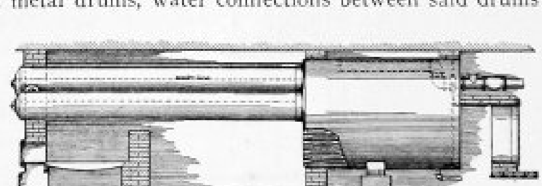
Claim.—A tube or flue cleaner comprising a casing, a fixed diaphragm in the casing, a fixed shaft held by and projecting inwardly from the diaphragm, a rotary motor element loosely operating around the shaft and provided with a forwardly projecting rigid extension, anti-frictional devices interposed



between the shaft and the rotary motor element, and a single cleaning head having a shank loosely and separably connected to and within the forward end of the extension in advance of the shaft, the cleaning head and its shank having movement in opposite lateral directions in addition to the rotary movement imparted thereto by the rotary motor element. Seven claims.

874,389. STEAM GENERATOR. Thomas Reed Butman, of Lake Bluff, Ill.

Claim.—In a steam generator, a series of parallel, relatively thin metal drums, water connections between said drums near



one end, a shell of relatively thick metal of greater cross sectional area than the combined cross sectional areas of the drums, wherewith said drums connect to open freely into the upper part thereof, fire tubes extending through the lower portion of the said shell and a grate beneath the drums. Seven claims.

875,263. RIVETED JOINT. August Hertwig, of Aix-La-Chapelle, Germany.

Claim.—A riveted joint comprising metallic parts provided with rivet holes in register and having a recess adjacent each of said rivet holes, a rivet provided with heads having a flat

inner surface of each, and a projection upon said flat inner surface of each of said rivet heads for filling said recesses to increase and safeguard the sliding resistance and the tightness of the joint. Four claims.

THE BOILER MAKER

VOL. VIII MARCH, 1908 No. 3

THE BOILER SHOP OF THE HARLAN & HOLLINGSWORTH CORPORATION.

BY CHARLES S. LINCH.

One of the most modern boiler shops in the United States is that at the shipyard of the Harlan & Hollingsworth Corporation, Wilmington, Del., of which Mr. Daniel Gibson is the foreman boiler maker. The building is of steel and brick construction 300 feet long and over 124 feet wide, and was built by the American Bridge Company. As shown by the photographs photograph of the finished structure, by the use of many large windows placed near together. It is heated by steam.

The shop is well equipped with traveling cranes for handling the work, all of which are electrically driven. Electricity is also used to drive all machine tools, the power being distributed by independent motors, built by the General Electric Company.

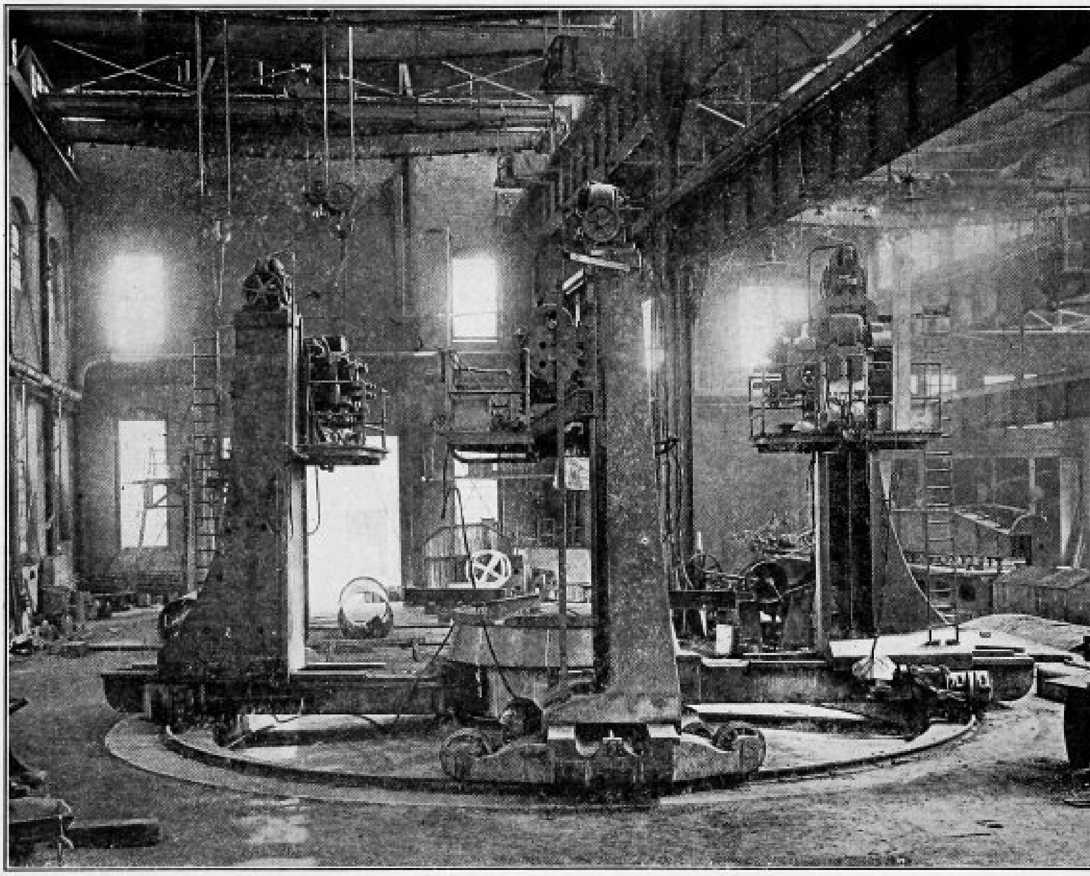


FIG. 1.—SPECIALLY DESIGNED BOILER-SHELL DRILL IN THE WEST BAY.

it is divided into three aisles of the following dimensions: One side aisle, 53 feet 7 inches wide, center to center of columns, with a clear height of 57 feet 3 inches; one side aisle, 29 feet 2 inches wide, center to center of columns, with a clear height of 28 feet, and a center aisle, 39 feet 7 inches wide, center to center of columns, having a clear height of 40 feet 9 inches. The building is a fine specimen of modern steel structural work, as it is light and exceptionally strong. The shop has been built with a view of securing as good light as possible for the interior, and this result has been obtained, as can be seen by the

The electric current is generated in a central power house, which supplies power for the entire shipyard and works. The power house, which is under the care of Mr. James Marshman, chief engineer, is a building of steel and brick construction, 190 feet long and about 60 feet wide, not including the boiler house. Steam is furnished by the 500-H. P. Stirling water-tube boilers, at a pressure of 150 pounds per square inch. The products of combustion are carried off by a flue from the three boilers leading to a stack 8 feet in diameter and 150 feet high. From a railroad track in the yard a spur runs to the boiler house, so that all the coal used for generating power is brought directly into the yard upon cars. From the cars the coal is conveyed from a hopper underneath the track to the bins outside the boiler house. The bins have a capacity of 800 tons of coal, and the conveyors, which were built by the Link Belt Engineering Company, Nicetown, Philadelphia, Pa., have a capacity for delivering 60 tons per hour.

A Reilly feed-water heater 36 inches in diameter delivers the feed water to the boilers at a temperature of 190 degrees F. The water is pumped from the heater to the boilers by two Warren feed pumps having cylinders 10 inches by 6 inches by 12-inch stroke.

Two McIntosh & Seymour cross-compound, vertical condensing engines, with cylinders 15 inches by 32 inches by 30 inches stroke, are direct connected to General Electric generators of 250 volts, 1,200 amperes. These engines develop 500 indicated horsepower at 150 revolutions per minute, with a steam pressure of 150 pounds. The main condenser is cylindrical, the combined air and circulating pump having cylinders 12 inches by 16 inches by 16 inches by 16 inches stroke.

The main engines are for day service. There is also one 50-kilowatt marine type generating set for night service, which was built by the General Electric Company, and one 150-horsepower Curtis turbine direct connected to two General Electric generators of 125 volts, 600 amperes each at full load. When the pressure at the throttle of the turbine is 150 pounds per square inch it runs at a speed of 2,400 revolutions per minute. The condenser for the turbine was built by the Wheeler Condenser Company. It has a combined air and circulating pump 7½ inches by 10 inches by 10 inches by 10 inches stroke.

Compressed air for the yard and boiler shop is furnished by Franklin air compressors of the cross-compound type, having cylinders 17 inches and 24 inches by 18 inches stroke. Hydraulic pressure for the hydraulic riveter is obtained by means of a Worthington pump, having steam cylinders 17 inches diameter by 16 inches stroke, and a plunger at the water end 3 7/16 inches diameter. This pump supplies water at a pressure of 1,750 pounds per square inch.

Besides the main engines and their auxiliaries there is in the power house a fuel oil pump 3 inches by 2 inches by 5 inches stroke, which draws a supply of oil fuel from tanks in the yard. Compressed air for burning the oil fuel is supplied by a Clayton duplex air compressor, which has cylinders 19 inches by 14 inches by 9 inches stroke. There are also two Worthington fire pumps, 18 inches by 10 inches by 12 inches, which at 70 revolutions per minute have a capacity of 10,000 gallons per minute.

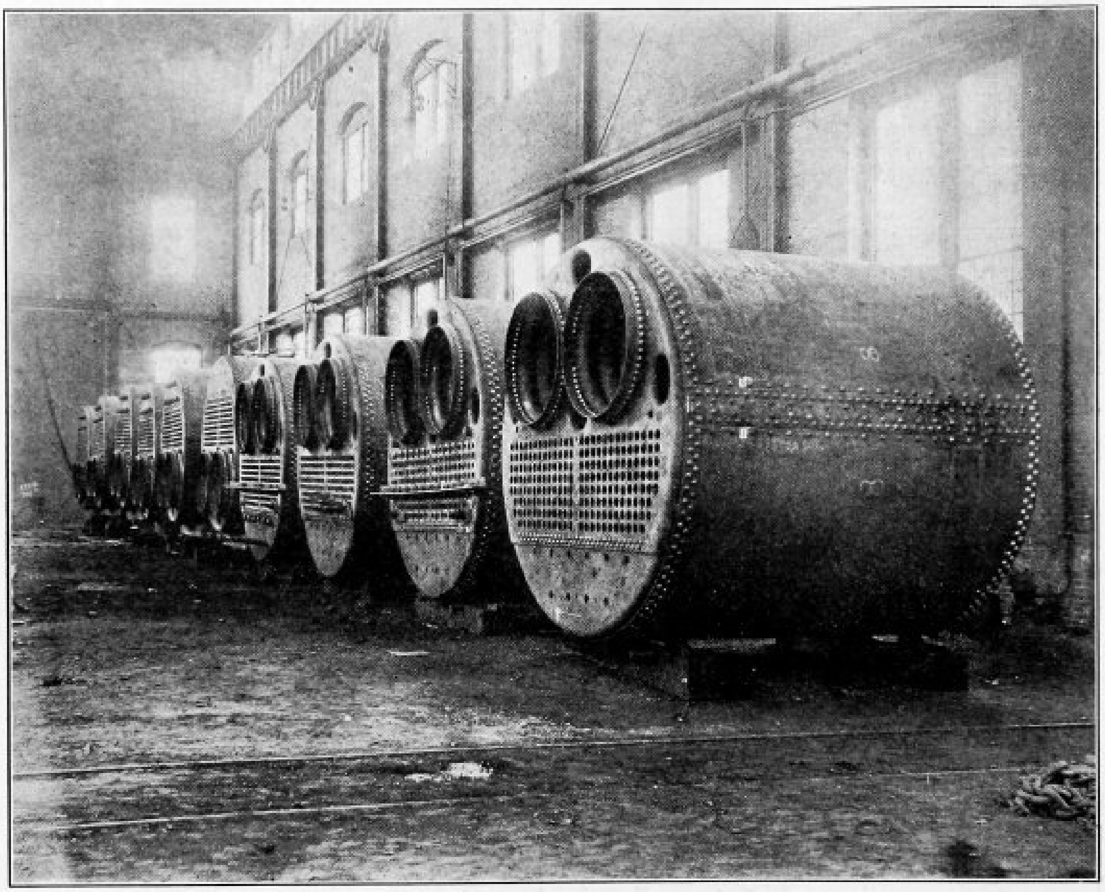


FIG. 2.—VIEW ON THE ERECTING FLOOR IN THE WEST BAY, SHOWING COMPLETED BOILERS.

Material which is used in the boiler shop is taken from a spur track, which runs along one side of the building, by locomotive cranes and delivered to any point in the shop as required. After the material reaches the shop it is very efficiently handled by the overhead electric traveling cranes built by the Alliance Machine Company and installed as follows: In the 53-foot side bay there are two cranes, each of 50 tons capacity; in the 29-foot bay there is one crane of 15 tons capacity, while the middle bay is served by one 25-ton crane. In addition to the overhead cranes individual machines are supplied with jib cranes and chain hoists where it is necessary to hold the work at the machine.

Starting at the south end of the middle aisle of the shop the first machine on the right-hand side is a thread cutter, which is used for cutting fore and aft stays and for cutting

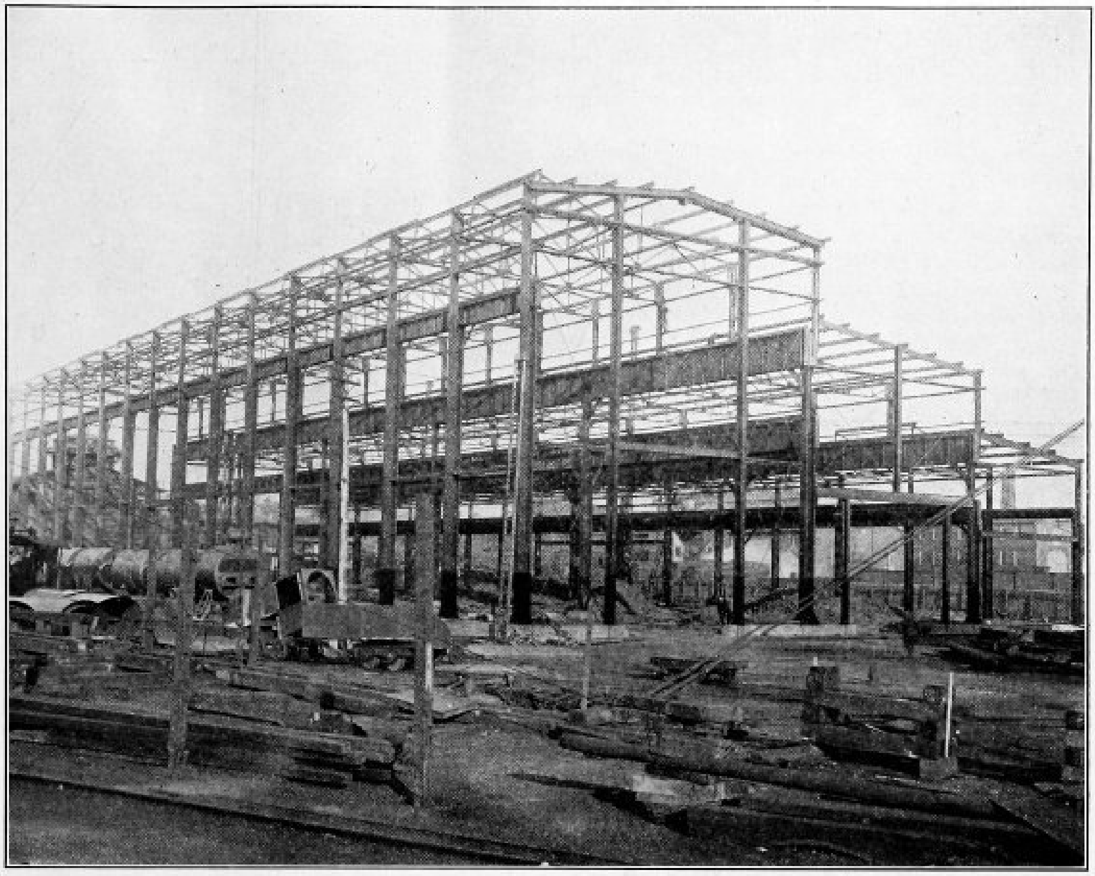


FIG. 3.—VIEW OF THE SHOP UNDER CONSTRUCTION, SHOWING ARRANGEMENT OF BAYS AND RUNWAYS FOR CRANES.

FIG. 4.—EXTERIOR OF THE COMPLETED SHOP.

Acme threads from 2 up to 4 inches diameter. Besides this machine there is a triple head bolt cutter for screw stays up to 2 inches diameter. Beyond the bolt cutters are two small drill presses for drilling tell-tale holes in the ends of stays. These machines are driven by a single motor from a short counter shaft.

Beyond the drills is a set of 17-foot horizontal light bending rolls, which are used for bending plate up to ¾ inch thickness. These rolls were built by the Bethlehem Steel Company, and are driven by a separate motor, which is geared directly to the machine. Near the bending rolls is a three-head tube hole machine of special design. This machine has a traveling bed and cross-heads, which enable the tube sheet to be drilled and the tack holes put in the flange with one setting of the machine. Another machine of special design and construction is

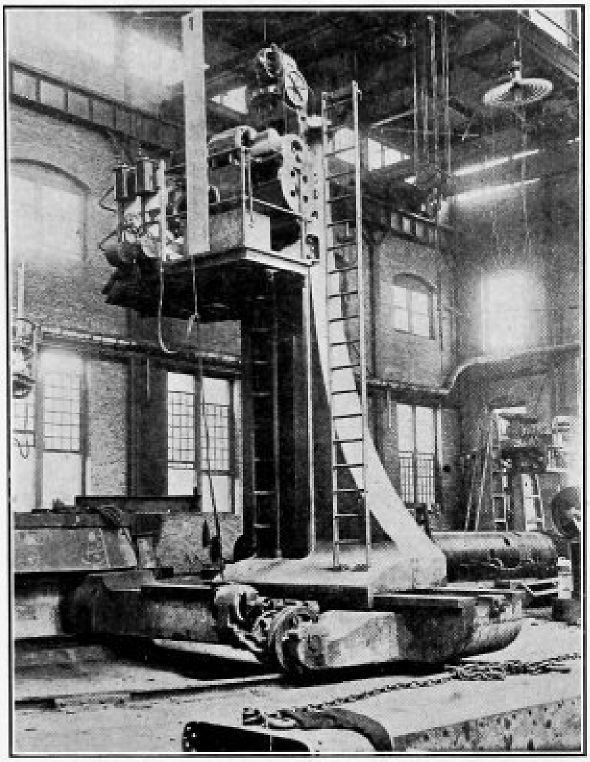


FIG. 5.—ONE OF THE HOUSINGS OF THE BOILER-SHELL DRILL.

used for making all round or oval openings in plates, such as manholes, handholes, etc. With this machine an oval can be put in in any direction and the front finished in one setting. Both of these special machines were built by the Bethlehem Steel Company and are motor driven.

In the punching and shearing department is a No. 4 Hilles & Jones punch, driven by an independent motor and served with a jib crane equipped with a chain hoist, one No. 6 Hilles & Jones combination punch and shear with a 48-inch gap, also driven by an independent motor and supplied with a jib crane and chain hoist. On the opposite side of this bay are one Cleveland punch and shear, two No. 3 Hilles & Jones punches with 36-inch gaps, one Hilles & Jones flange punch with 8-inch gap, one Hilles & Jones splitting shear, one Hilles & Jones No. 2 punch with 30-inch gap, one Lennox rotary bevel shear and one small set of light sheet iron bending rolls 6 feet long between housings. The last six machines are driven by a short length of line shafting. This is the only line shafting used in the building, as all other machines are driven by independent motors.

Beyond the punches and shears there is a heavy radial drill for drilling brace holes 3 and 3½ inches in diameter. This drill is bolted direct to one of the steel columns, and is driven by an independent motor. There is also one 6-spindle multiple drill, built by the Niles Tool Works, which is used for drilling holes up to 1¼ inches diameter.

Another machine of special design, which was built by the Bethlehem Steel Works, is a set of vertical bending rolls. These rolls have a capacity for bending plates 12 feet 6 inches wide and 2 inches thick, and are motor driven.

On the left-hand side of this bay, in addition to the punches and shears which have been mentioned, there is a large plate edge planer, which has a wide field of usefulness. The planer is geared directly to a motor and will plane a clear length of 34 feet in one setting. Besides the planer there is also a drill press bolted to one of the columns with an arm, which gives an effective radius for the drill of 11 feet. The machines in this end of the shop are served by a 25-ton electric crane built by the Alliance Machine Company, of Alliance, Ohio.

At the south end of the east bay of the shop is located a finely equipped tool room, and above this tool room is the space devoted to laying out. On the west side of the bay is a radial drill press for light drilling, which has a clear radius of 4½ feet. This drill is also driven from the line shafting which was mentioned above. It was built by the Niles Tool Works. On the east side of this bay are located the fires for flanging and smith work. Besides four flange fires for fitting purposes there is one 80-ton flanging machine, built by the Morgan Engineering Company, on the well-known Twedell system. The 80-ton flanger is served by one circular fire and one round fire, the work being handled by a 5-ton hydraulic jib crane. The work at the four fitting fires is handled by means of two 5-ton hydraulic cranes.

A large oil-burning furnace for straightening and annealing plates is built into the north and west walls of the shop. The furnace is 12 feet wide by 20 feet deep, and in front of it are located the slabs for straightening plates.

The west bay is served by two 50-ton cranes, built by the Alliance Engineering Company, one of which has a double trolley. The hydraulic riveter is located at the north end of this bay, and is a large machine having a 17-foot 6-inch gap. The different pressures that can be applied to a rivet are 25, 50, 75, 100, 125 and 150 tons. The riveter is the product of the Bethlehem Steel Company.

One of the most interesting machines in the shop is the specially designed boiler shell drill, photographs of which are shown. This machine, which was also built by the Bethlehem Steel Works, has three heads, each head being equipped with four spindles. The boiler shell is placed on end on the center table, while the heads have a vertical movement on the housings, and the housings a circular motion around the shell, as shown by the circular track. Thus with this machine rivet holes can be drilled rapidly and accurately at any height as well as in any position on a circular shell.

The stay-bolt holes in the back heads of the boilers are to be drilled and tapped by means of a four-spindle horizontal drill. At the present time this machine has not been set up, but it is to be in operation shortly. The remainder of the west bay is left free and used as an erecting floor. A complete test room is being built for the purpose of testing completed boilers, but the equipment has not yet been installed.

Along the west wall of the shop, that is, in the bay which is used as an erecting floor, are placed a number of Knatt rivet-heating furnaces. One of these furnaces is also placed on the platform of the hydraulic riveter. Compressed air for these furnaces is supplied by a blower located on a platform about 15 feet from the ground in the north end of the west bay. The switchboard for controlling the power in the shop is also located on this platform.

Estimating the Cost of Repair Work.

BY JAMES CROMBIE.

In the January issue of the BOILER MAKER a very interesting and helpful article was published regarding the cost of a return tubular boiler. In the present article the writer will take up in a somewhat similar manner the estimation of the cost of a few repair jobs, trusting that some of our successful veteran boiler makers will be led to do the same and thus give the younger men in the trade the benefit of their experience on this important point.

In a contract shop one is called upon to face all kinds of problems, especially in a shop where much repair work is carried on. It may be that a steel mast must be replaced or that several plates must be taken from the bottom of a steamboat, and the floor plates, frames and plating in the way of repairs made good, or it may be that 30 or 40 feet of the bulwarks must be taken down and renewed, or the bow of a boat may have been smashed in a collision, so that the stem and shell plating are badly twisted, all of which must be made good to pass the inspector. It may be necessary to put in new coal bunkers or to take down the old funnel or smokestack and erect a new one. The donkey or upright boiler may be in need of repairs. Several photographs were published in the BOILER MAKER during the past year showing how one of these boilers had blown up, tearing up the deck of a steamship and blowing the main funnel overboard. Repairs may be necessary on a water-tube, locomotive, return-tube, Scotch marine, or any other type of boiler, but in every case, no matter how large or how small the job, the question with which we are confronted is: "What is your price on the job?"

The foregoing gives but a suggestion of the many different phases of repair work on which it is necessary to estimate the cost and to estimate it correctly, not only so that there will not be any loss, but also so that the price will stand favorably as a competitive bid.

Take the following job of repair work as an example. The price is asked on the work necessary to renew the fire-box or cone of an upright or donkey boiler, including a new up-take pipe and a new collar or flange to fit the up-take pipe and outside head. In the following analysis no account will be taken of the cost of material, as that is not so much a question of estimation, since it can be figured out exactly.

Assume that the boiler is 36 inches in diameter, 6 feet 6 inches high and has two cross-tubes riveted in the cone. The up-take pipe is 8½ inches in diameter by 33 inches long. The top of the cone is flanged in the center to fit this pipe, the pipe then extending up through the crown or top of the boiler. It was found that the flange for the pipe on the outside was pitted and grooved so that it had to be cut off and a new collar made to fit the pipe, this collar, of course, to be riveted to the top of the boiler.

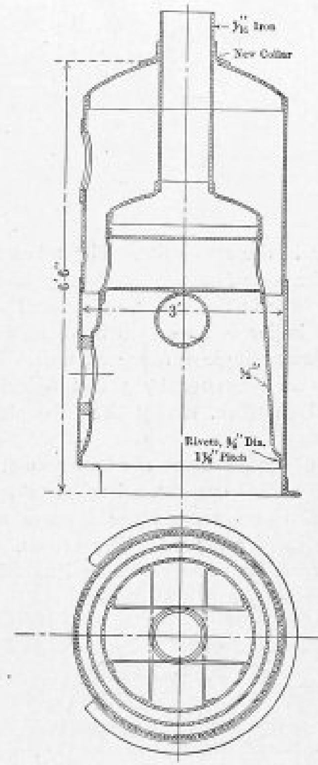
A fair estimation of the time taken for this work would be as follows: Removing the old fire-box, a boiler maker and an apprentice, 17 hours; flanging the bottom of the cone to fit the outer shell, which is 36 inches in diameter, and recessing the fire-door hole, welding the up-take pipe, which is 8½ inches in diameter and 33 inches long and made of 7/16-inch Lowmoor iron, and flanging the collar for the up-take pipe (the collar must be machine flanged and all the other work hand flanged) will take a boiler maker 22 hours and two helpers 22 hours each; laying out the new cone (two plates in the cone), punching, scarfing four corners, rolling up, fitting in the head and two cross-tubes, riveting up on the hydraulic machine, calking and testing the job will take a boiler maker 170 hours, an apprentice boiler maker 30 hours, helpers 130 hours and a boy 30 hours.

Total time on the job:

	Cents Per Hour.	Hours.	
Boiler maker	24	209	$50.16
Apprentice boiler maker....	10	47	4.70
Helpers	15	270	40.50
Boy	10	30	3.00
Estimated cost of labor..........			$98.36

All material extra (two cross-tubes were bought, welded and flanged, but had to be fitted into the boiler, allowance being made for this in the above estimate for the time of the helpers).

As another instance of estimating the cost of repair work, figure out the cost of converting an old land or Galloway type boiler into an oil tank. The boiler is 30 feet long, 8 feet mean diameter; all rivets ⅞ inch in 15/16 holes, machine driven.



JOB NO. 1.—VERTICAL DONKEY BOILER.

The work required for this job is as follows: Removal of two flues, closing up of the flue holes at each end of the boiler, calking and testing with cold water.

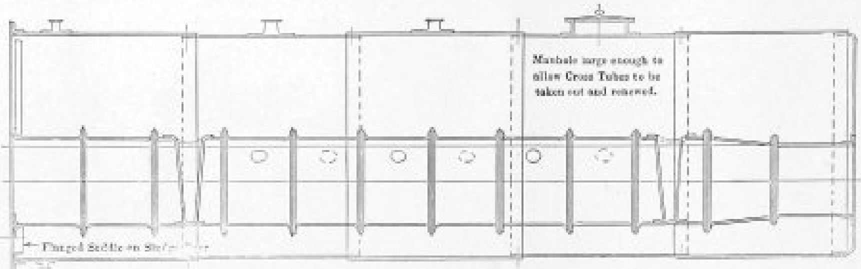
Both flues must be cut at each end where they are riveted to the boiler heads, and the front head must be cut out in order to allow the flues to be taken out. Cutting out the rivets from the back end of the flues, the front end of the boiler and all the rivets attaching the gusset stays to the front end plate would take two boiler makers 20 hours each. The flues would have to be worked out with chain blocks and rollers if there were no crane near the job. Taking out the flues and fitting on the front plate, also fitting on two plates, each 36 inches in diameter, and two plates, each 42 inches in diameter, to cover the flue holes in both the front and back boiler heads would take one boiler maker 36 hours, an apprentice boiler maker 40 hours, and helpers 165 hours. The time required for riveting, including the riveting of the front head to the shell, also to the gusset stays and the riveting of the four plates on the flue holes, would be as follows: One boiler maker 49 hours, one helper 39 hours, one boy 24 hours. The calking and testing would take one boiler maker about 30 hours.

Total time on the job:

	Cents Per Hour.	Hours.	
Boiler maker	24	125	$30.00
Apprentice boiler maker	10	40	4.00
Helpers	15	204	30.60
Boy	10	24	2.40
Estimated cost of labor			$67.00

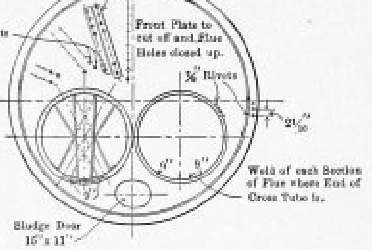
All material extra.

As a third example of the estimation of the cost of repair work consider the repair of a small Scotch marine boiler. On examination it is found that the water has been allowed to get low, causing the crown sheet and back of the fire-box to buckle and draw in the stay-bolts. The tubes are also in bad condition and the sides of the fire-box grooved and pitted. There is no manhole in the boiler, only small sludge doors or handholes. The boiler is 42 inches in diameter by 84 inches long, and contains a single furnace 22 inches in diameter, 23 tubes 2½ inches in diameter by 5 feet 6 inches long. The plates are 5/16 inch thick, except the tube plates, which are ⅜ inch thick.



JOB NO. 2.—GALLOWAY BOILER.

To do this job in good shape the boiler must be sent to the shop and the back head cut out, all tubes taken out, all stay-bolts cut out, all rivets around the furnace mouth cut out, and the furnace itself removed. The crown, sides and back of the fire-box must be removed as well as all the stay-bolts



END VIEW OF GALLOWAY BOILER.

and tubes. Of course, in laying out the riveting and stay-bolt work, one must be governed by the stay-bolt holes and rivet holes which are already in the boiler. There are eighty-two stay-bolts, seventy-two rivets around the flange of the back head, and thirty-eight rivets around the furnace mouth, besides those connecting the fire-box to the inside tube sheet and tubes. The rivets are ¾ inch in diameter, spaced 1⅞ inches between centers.

The quickest way to get the boiler apart would be to drill the stay-bolts out of the shell plate on each side. Then cut and back out the rivets in the flange of the back head and at the furnace mouth and cut the tubes at the front end. The boiler could then be turned up on end and the back head, together with the fire-box, furnace and tubes all lifted out of the boiler at the same time. The stay-bolts could then be broken off between the back head and the fire-box, after which the head could be taken to the drill and the pieces drilled out. If the tubes are not beaded at the fire-box end they could easily be worked out of the tube holes and the tube plate cut adrift from the fire-box.

The cost of the above work would be estimated as follows: Cutting out, two boiler makers 18 hours each at 24 cents an hour; total, $8.64; laying out, spacing the holes in the flange of the fire-box back sheet after it has been flanged, 1 hour at a cost of 25 cents; shearing and flanging the back sheet of the fire-box, which is 36 by 28 inches, finished size, the flanging to be done on a hydraulic machine, one boiler maker 1½ hours at 24 cents per hour, two helpers 1½ hours at 16 cents each per hour; total cost 84 cents. Rolling the side sheets, fitting up the side, top and back sheet of the fire-box, also punching all stay-bolt holes for 1-inch stay-bolts; one boiler maker 19 hours at 24 cents per hour, two helpers 15 hours at 15 cents per hour each; total cost $9.06.

The fire-box can be riveted around the flange of the top sheet and across both seams at the bull machine and then calked inside before the back sheet is bolted on. The fitting up and riveting at the bull machine would require 2 hours' work for one riveter at 20 cents per hour, two hours for one helper at 16 cents per hour, and 2 hours' work for one boy at 10 cents per hour, making the total cost 92 cents.

The back sheet of the fire-box must then be riveted up by hand; since a man could not go into the fire-box, the rivets must be held on through the tube holes. Riveting up this plate would take two boiler makers 3 hours each at 24 cents per hour, one holder-on 3 hours at 16 cents per hour, and one boy 3 hours at 10 cents per hour, making the total cost $2.22. Drawing the furnace and fire-box into place and bolting it up ready for riveting would take one boiler maker 5 hours at 25 cents per hour, two helpers 5 hours each at 15 cents per hour, making the total cost $2.75.

There are 110 rivets to drive around the furnace mouth and backhead, all of which must be driven with a pneumatic hammer, taking about 3 minutes for each rivet. Including turning the boiler around on rollers, this work would take one riveter about 5½ hours at 20 cents per hour, two helpers 5½ hours each at 15 cents per hour, and one boy 5½ hours at 10 cents per hour, making a total cost of $3.30.

By slinging the boiler from the flange of the back head, the furnace mouth could be riveted on the bull machine, and then by turning the boiler upside down and suspending it from the tube holes, the back flange could also be riveted up on the bull machine. Although sixty rivets could easily be driven per hour with the bull machine, in order to allow for the time taken to sling the boiler and turn it upside down, it would be safer to allow 1.34 hours for driving sixty rivets. This would take one riveter 2½ hours at 20 cents per hour, one helper 2½ hours at 16 cents per hour, one helper 2½ hours at 15 cents per hour, one boy 2½ hours at 10 cents per hour, making the total cost $1.53. Thus we see that by driving these rivets on the bull machine the work can be done for $1.53, whereas when driven with a pneumatic hammer the cost is $3.30, making a difference of $1.77 in favor of hydraulic riveting in this case. Therefore it would be better to use the hydraulic riveter, not only as it is cheaper, but also because better work can be done than with the pneumatic hammer.

Tap all the stay-bolt holes, run in the stay-bolts, fit them and cut them off with the machine. With a good air drill each hole can be tapped in 1 minute. Allowing 6 minutes as the total time required for each staybolt, for eighty-two stay-bolts the total time would be approximately 8½ hours, requiring two men at 16 cents each per hour, or making a total cost of $2.72. Riveting up the stay-bolts would take two boiler makers 9 hours at 24 cents per hour, and one helper 9 hours at 16 cents per hour, making a total cost of $5.76.

It would take a boy about 1½ hours to get the new tubes from the storeroom and grind off the sharp edge from one end of each tube, making a cost of 15 cents. Inserting and expanding the tubes would take one boiler maker 10 hours at 24 cents per hour, making the total cost $2.40.

Inserting the through stays in the steam space at the top of the boiler, of which there would be two 1⅛ inches in diameter, would take one boiler maker 2 hours at 24 cents per hour, costing 48 cents.

The remaining items of this job are testing; two boiler makers 5 hours each at 24 cents per hour, making a total of $2.40; taking off and replacing valves and fittings; one engineer 20 hours at 22 cents per hour, costing $4.40, and fitting on the up-take, two helpers 5 hours each at 16 cents per hour, costing $1.60.

Having found the cost of each different operation we will now find what the total cost is:

Cutting out	$8.64
Laying out	.25
Shearing and flanging back of fire-box	.84
Fitting up fire-box and punching stay-bolt holes	9.06
Riveting fire-box at hydraulic riveter	.92
Hand riveting back of fire-box	2.22
Drawing furnace into place in shell of boiler	2.75
Riveting furnace mouth and back end of boiler, hydraulic riveter	1.53
Tapping holes and fitting in stay-bolts	2.72
Riveting stay-bolts	5.76
Boy getting out tubes from stockroom	.15
Inserting and expanding tubes	2.40
Inserting through stays	.48
Testing	2.40
Fitting on old up-take	1.60
Engineer at valves, etc	4.40
Estimated cost of labor	$46.12

Adding 5 percent for unexpected expenses, as the furnace may be tight or the stay-bolt holes may be pitted inside and require tapping out for large stay-bolts, our total now is $48.43, say $49.00.

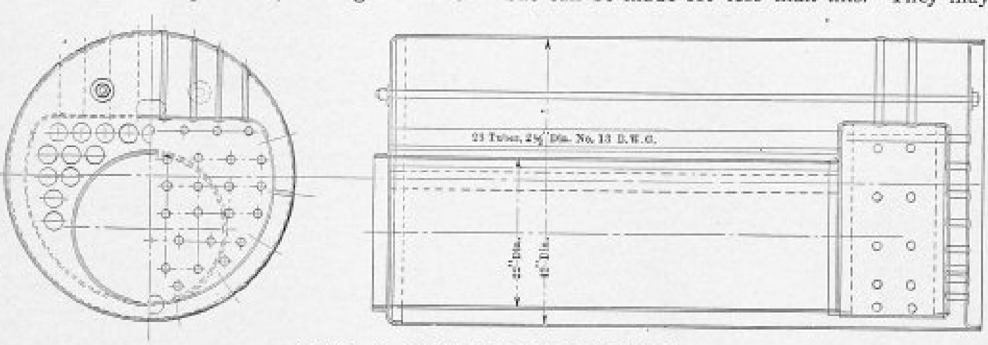
The new material required for the entire job and its cost is as follows:

One plate 41 by 32 by 5/16 inch for back of fire-box One plate 72 by 15 by 5/16 inch for sides of fire-box One plate 42 by 15 by 5/16 inch for top of fire-box	263 Lbs.
All flange steel at 2¼ cents per pound	$5.92
126.5 feet 2½-inch diameter tube at 15 cents per foot	18.98
Rivets, 75 pounds at 3½ cents per pound	2.63
Eighty-two stay-bolts at 20 cents each	16.40
Fusible plug	.75
Total for material	$44.68
Total for labor	49.00
Total for material and labor	$93.68
Thirty percent for fixed charges	28.10
	$121.78
Profit, 10 percent of total	12.18
	$133.96

The total estimate for the repairs would be quoted at $135.

The stay-bolts in this estimate are quoted at 20 cents each, but can be made for less than this. They may be made like rivets in the rivet header, six being squared on the head and cut off at each heat. With a good long heat on the bar and the fires kept full, a man can make from 300 to 500 per hour. A handy man at 18 cents per hour will thread 120 per hour in a good machine.

In the early part of this article the writer has not given the material, as that is always an easy matter to work out; it is the time that is the most uncertain thing to figure on. We must know our men when we are working out our estimates and decide who will be the best man to put on each class of work.



JOB NO. 3.—SINGLE FURNACE SCOTCH BOILER.

Oil Fuel.

Petroleum is being used extensively as a fuel, not only on the Southern railroads of the United States, where the location of the road near the oil fields assures a vast supply of such fuel which is both accessible and economical, but also in the warships and navies of foreign countries, which are obliged to import nearly all of the oil which they use. At present Great Britain makes use of oil as a supplementary fuel in many of her largest battleships and cruisers. The huge *Dreadnought* carries a supply of 1,500 tons of it, while several of the torpedo-boat destroyers use it exclusively. Great Britain is dependent for the larger part of this fuel on the United States. In 1906 the United States produced 4,587,000,000 gallons of petroleum, while the next largest source of supply, which is the Baku fields of Russia, produced only 1,846,000,000 gallons. The quantity exported from Russia was very considerably less than that exported from the United States. That the amount exported from both of these fields, and especially from the United States, will be greatly increased in the next few years is practically certain. The British Admiralty alone is providing for the construction of immense storage tanks for oil at Portsmouth and Plymouth. Tanks are to be erected at Portsmouth capable of holding 20,000 tons, and possibly more. In addition to this, one tank ship has already been built by the British Admiralty for transporting fuel from Texas to Great Britain, and it is understood that within the next few years a fleet of perhaps twenty tank ships will be in commission for this purpose.

Honest Work.

BY JAMES ROSSAN.

Grave charges had been launched against one John Saunders, who was the owner of a boiler shop in one of the busiest lake ports. As yet no boiler trust had developed, so they were not charges of acts in constraint of the trade. But they were worse; they were charges of graft. For some cause or other all the trade of the port had gone to Saunders of late, and his competitors were loud in their complaints, charging him with both graft and coercion in order to obtain a monopoly of the trade.

I was the man sent to investigate, and found conditions baffling. They were a curious lot around the waterfront of this old lake port, taciturn and stolid; men who minded their own business and cared not how wagged the rest of the world. The installation and repairing of boilers and machinery in the huge crafts at the docks presented a busy scene. It was a fact that the shop owned by Saunders did all the work, but approach one of the men on the subject and immediately he would become the silent Carthusian.

There seemed to be but one subject those men would talk on, and that was the gale, the big gale of September. A half dozen big, black, twisted hulks lying on the beach near the harbor bore evidence to its force. But it will, perhaps, be best to tell of the gale in the words of one Flynn. Flynn is a man of parts about the port; he can talk. This, in connection with the fact that he was an officer of the only ship that came through the gale, has made him a famous man. He is the keeper of a tavern and is waxing fat on the spoils of the curious.

"Yes," he began, after I had done the handsome thing at the bar. "We were nearing the harbor, running before it when the snow set in so thick that it would have been sheer madness to attempt entering. So we brought her about and headed her into it. And, Oh! h——! after that it was just water and water and water; tons and tons and tons of it. Everything movable went overboard. Rivets snapped and shot out like rifleballs. Plates and beams twisted and bent as if they were made of putty. But, believe me sir, the *Monarch* didn't budge an inch; no, sir, she didn't peeter out and drift on the beach stern forninst like the rest of them. She stayed right there bucking it until the gale wore itself out, and then we entered the harbor in smooth water. And I believe if Old Nick himself had had a 6-inch cable on her he couldn't have budged her an inch nearer the shore."

"And how was that?" I ventured.

He leaned close to me and answered in a whisper: "You see, McDonald was engineer of her, and he worked her. God bless him, how he did work her!" That was about all the information obtainable from Flynn, and my next move was naturally to find McDonald.

I found him in the company of Saunders. I had been told that they were inseparable chums. We found much to talk about. Saunders was the busiest manufacturer of the place, and McDonald had lately been elevated to the position of chief engineer of the proudest fleet sailing from the port. They were successful men, men of energy, men of strength and daring. But touch the subject of the heroism displayed in bringing the *Monarch* in through the gale and immediately they froze and became as silent as stone. They were not men of emotion and sentiment.

It became evident that I had to look farther, and in due time it came. Fagan, the oldest boiler maker of the place, told it. And he told it while lying on his back driving a ¾ rivet with a 14-inch swing to his hammer.

"Shure," he said, "Oi was one of the first ones to work for Saunders whin he started the little old shop. And it was the queer cuss he was. Niver a minnit did Oi think he'd amount to what he is to-day. Somehow there didn't seem to be any business in the chap. It looked as if he was always afraid that he wouldn't get a job good enough; he was what Oi'd call, slow. Now, if ye'll stand a bit to one side, out o' me light, Oi'll tell ye about what sort o' an ohmadhaun he was. Blinky-eyed Burnham was foreman for him then. The same Burnham what started for himself later, and went up the spout last summer. Blinky was the smart one. When we were on the first real big job the shop had, a big 14-foot Scotch kettle, we found that after flanging and fitting one of the heads, there was a 16-inch crack right across it. Saunders, whin he saw it, nearly threw a conniption fit. But Blinky, the foreman, tapped him on the shoulders soft like and said: 'It's all right, Old Man, shure Oi'll fix that up. Oi kin plug that so no man will ever see it.' Oh, Oi tell ye that Blinky was a smart one. Oi meself knew he could do it, for Oi had seen it many a toime. Well, sir, Saunders wint to the office and sat down with his head in his hands for a long toime. Oi guess, he just naturally had to have it out with himself. He thin came back in the shop loike a man possessed, grabbed Blinky by the shoulders and said: 'Cut that head out and throw it away.' Ye can belave me or not, but Oi thought the man had gone daffy, and so did the rest of them. We knew what it meant to him, just starting in, to throw away a boilerhead. Blinky tried to argue with him and towld him of a dozen cases where he had done it. 'Why,' says he, 'ye remimber those big boilers they turned out last summer over at the big shop of Thompson's for the boat called *Miami?* Well, sir, there were cracks 2 feet long in those boilers, and they never showed a sweat under the test after Oi doctored them up.' But it was no use, we had to cut it out. Saunders carried on like a crazy man, and kept saying: 'If a man buys a boiler he don't buy a lot of scrap-iron.' After that there was all sorts of trouble, waiting for a new head. Time expired on the contract, and, Oi guess, it was a case of no money too. Oi belave to this day that he would have gone up the spout if it hadn't been for that McDonald. He was going engineer of the boat the boiler went in, Oi belave they called her the *Monarch*, and that engineer-chap had a pull and smoothed it over some way." Here the old fellow had a hot rivet jumping out of the hole every time he hit it, and shouted to the man inside: "Get on there, ye ornary brat, or Oi'll knock it clane through ye!" Then to me again: "Shure, it's a pity the min we have to work with now-a-days!"

The rest of the story was a long time coming. But at last it arrived. And it came from a tattling clerk who was working in the offices of the steamship company. I doubt if this man served the best interests of his employer, because he told tales from the inner sanctum which should have been held sacred. I will let him tell it in his own words.

"Holy Moses, but it's fierce the way the Old Man and that McDonald, who is chief engineer, carry on sometimes. They fight like cats and dogs. Only the other day the Old Man says to him:

"'Say, Mac! How much steam did you have on the boilers of the *Monarch* when you held her out there in the big gale?'

"The engineer looked at him kinder queer like, and answered:

"'I don't know.'

"'Jim McDonald, you are a liar!' the manager snapped back at him.

"'No, I am not!' the engineer answered, waxing hot around the collar. 'And now while we are on the subject, I might as well say, that Saunders is going to have the contract for the boilers in those six new steamers we are building.'

"The Old Man looked at him sharp like, and said: 'Yes, if he is the lowest bidder.'

"'Highest or lowest, I don't care which, he gets it!' McDonald shouted.

"'There are vast possibilities in that, Mc.,' said the manager, looking at him through the narrow slits of his partly closed eyes.

"'Now, look-a-here!' the big engineer continued, jumping to his feet and shaking his fist under the Old Man's nose. 'I am honest, and you know it. So we will leave that out. But there are certain things about which we can not afford to take any chances, no matter what the consideration. And one of them is the boiler of a steamboat.'

"'Ah, I see where the shoe is pinching,' the manager interrupted. 'You refer to the fact that Saunders built the boilers for the *Monarch*, while those of the *Miami*, our other boat which foundered in a gale, were built elsewhere. But, remember Mc., perhaps the *Miami* was not properly handled.'

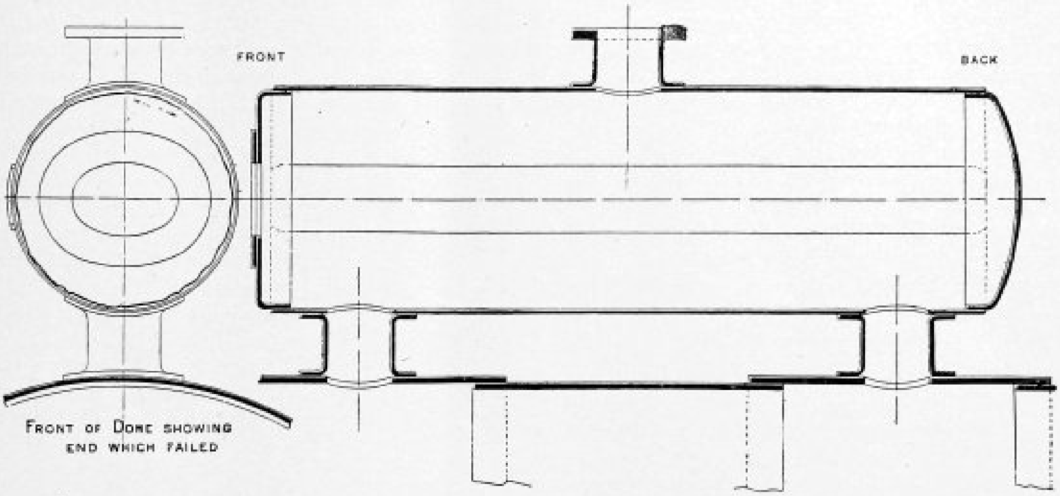
"'McDonald was still facing him with blood in his eye, and threw back at him: 'Old man Farnum was engineer of the *Miami*, and went down with her. He taught me everything I know about the trade. I knew him well enough, and was with him long enough to say that he was not the man to let his boat drift on the beach as long as rivets and braces held together. You can take poison on the fact that the *Miami* had her tryout.'

"'And we know she failed,' the Old Man supplemented. 'And we also know that the *Monarch* came through successfully. But when I ask you how much steam you had to carry to do it you tell me that you don't know.'

"'And I don't,' McDonald snapped back. 'It had gone far beyond the reckoning of the gage. No man knows how much steam was on those boilers. But all men know that there was sufficient to save the boat from wreck. And all men know that there were no flaws in those boilers, or none of us would be here to tell the tale.'

"'The Old Man sat thinking in silence a long time, then he said, slowly and deliberately: 'Mr. McDonald, the matter of boilers for our new ships is something which we leave entirely at the discretion of the chief engineer.'

"'And the chief engineer reached across the desk, took his hand and said: 'Thank you, sir.'"



DOME OF THE BOILER WHICH EXPLODED AT THE PARKFIELD MILL.

Explosion from a Boiler at Parkfield Mill, Nelson, Lancashire.

This boiler, which is one of a pair, is of the Lancashire type, and is 30 feet in length, and 8 feet in diameter inside. Each flue is 3 feet 2 inches in diameter inside, and is tapered at the back end. Five Galloway tubes are fitted to each flue. A horizontal dome 9 feet in length and 2 feet 8 inches in diameter was connected to the shell of the boiler by means of two necks 8¾ inches in diameter. The ends of the dome were flanged inwards and were secured to the shell of the dome by rivets ¾-inch in diameter, pitched 2¼ inches apart. The front end, which was flat, was fitted with a manhole door, the opening being 15 inches by 11½ inches. An outer compensating plate 4½ inches wide by ⅝ inch thick was riveted around the manhole. The back end of the dome was dished. The boiler and dome were made throughout of Siemens' Martin acid steel plates. The shell plates were ⅞ inch thick, and the dome shell and ends were 9/16 inch and ⅝ inch thick, respectively.

A stop valve was fitted on top of the dome, to which both boilers were connected by means of a pipe 8 inches in diameter.

The usual mountings were provided for each boiler, including a high steam and low-water safety valve and a deadweight safety valve, which were adjusted to blow off at 180 pounds per square inch; a steam pressure gage was also fitted.—*Page's Weekly.*

Cost of Maintaining Brick Furnaces.

It is a well-known fact that brick work deteriorates more rapidly with high than with low temperatures. But due to the fact that recent experiments and current engineering practice have shown that Dutch ovens and firebrick-lined furnaces are essential to smokeless and economical combustion of most fuel, it is desirable to know what additional expense will be entailed in a steam plant which is thus equipped, due to the deterioration of the firebrick. Mr. A. Bement has recently published some figures on this point, taking as a basis the cost of maintenance of two electric plants, each fitted with water-tube boilers and served by chain grate stokers, one of the plants being equipped with a tile roof furnace chamber, while the other had its boiler exposed directly to the fire, as is the common practice in many installations made by manufacturers. Presumably the other details of the two plants were similar.

It was found that the average cost per boiler for repairs for a period of two years was $250 for the apparatus with a tile roof furnace, and $170.48 for the apparatus without the tile roof chamber, showing that there was greater expense entailed for maintenance of brickwork in the plant having tile roof furnaces of about $80 per annum per boiler.

That is not the end of the story, however, as an important saving is effected in the plant fitted with the tile roof furnace. This saving is due to the fact that complete and smokeless combustion of the fuel is obtained, resulting in a higher efficiency of the boiler, or, in other words, a smaller coal consumption per unit of work. This saving of fuel amounted to about $1,000 per annum per boiler. So that the net gain due to the presence of the tile roof furnace and consequent higher temperature is about $920.

Layout of a Hemispherical Tank Head.

Fig. 2 shows both the plan and elevation of the end of a cylindrical tank which is provided with a hemispherical head. The hemispherical head is built up of a number of plates joined together with seams which are arcs of great circles on the sphere. The end of the head is formed by a dished plate, in order to do away with the awkward form of riveted joint which would be necessary if the various sections were continued to the top of the head.

The dimensions of the various plates forming the head are usually determined in the following way. Setting the trams at a length equal to the radius of the tank, that is ½ *D*, the elevation of the head is divided into three equal parts, as at points *L* and *T*. *LT* is then the diameter of the dished plate which forms the end of the sphere. With the trams still set at a length equal to ½ *D*, divide the circumference of the tank shown in the plan into six equal parts. With the trams set to a length equal to ½ *LT*, draw the plan of the dished plate and divide its circumference into six equal parts corresponding to the divisions in the circumference of the tank. The head is now divided into seven sections, six of which are exactly alike; the seventh being the dished plate. If the diameter of the tank is large, the head may be divided into a greater number of sections, since the number of sections does not affect the method of laying them out. The head may be made in seven sections for tanks up to 14 or 15 feet in diameter, as then the plates would be only approximately 7 feet wide and 7 feet long, but for tanks of greater diameter eight or nine sections would be used.

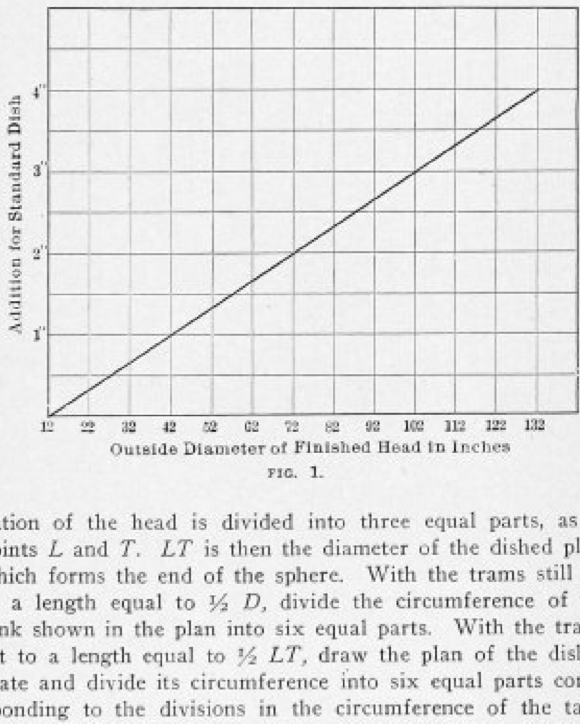


FIG. 1.

In Fig. 2 the dotted lines show the position of the rivet lines, while the solid lines show the edges of the plates. It is customary to make the dished plate, and also the first course of the cylindrical part of the tank, outside plates.

To lay out the dished plate it is simply necessary to strike a circle whose radius equals ½ *LT* plus a certain allowance which must be made for the extra material required when the head is dished. This allowance varies according to the diameter of the plate. Approximately the proper allowance is shown by the curve Fig. 1, on which are plotted in inches the necessary allowances for heads of different diameters. For example, if it is necessary to lay out a head which is to have the standard dish and be 72 inches outside diameter when finished, look on the curve for the diameter 72. The curve at this point, as shown by the vertical scale, reads 2 inches. That is, 2 inches should be added to the finished diameter of the head for the size of the plate when it is laid out before dishing. Therefore, when the plate is laid out it should be 74 and not 72 inches in diameter. Instead of using the radius *R* and making the above allowance, when laying out the head, a radius equal to the length of the line *LW* may be used, which will give at once the correct diameter of the plate.

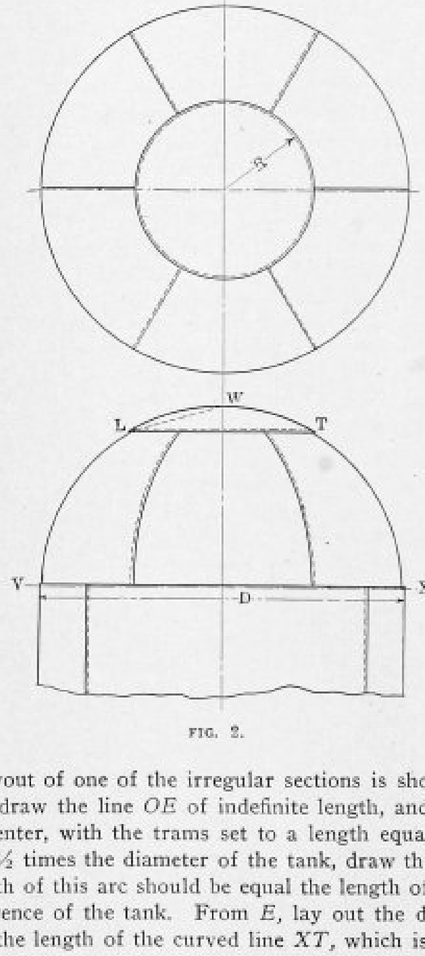


FIG. 2.

The layout of one of the irregular sections is shown in Fig. 3. First draw the line *OE* of indefinite length, and then with *O* as a center, with the trams set to a length equal to 1½ *D*, that is, 1½ times the diameter of the tank, draw the arc *DEC*. The length of this arc should be equal the length of 1/6 of the circumference of the tank. From *E*, lay out the distance *EF* equal to the length of the curved line *XT*, which is also equal to 1/6 of the circumference of the tank. Properly speaking, if the sections are not to be dished, but simply rolled flat, the line *EF* should be slightly shorter than 1/6 the circumference. The allowance is so small, however, that it may be neglected.

Having located the point *F*, next locate the point *M*, at a distance from *F* equal to 1½ times *R*, the radius of the dished plate. With *M* as a center, and with the trams set to the distance 1½ *R*, draw the arc *AB*, making the length of the arc *AB* equal to 1/6 the circumference of the dished plate.

Having located the points *A*, *B*, *C* and *D*, it yet remains to draw the curves *AD* and *BC*. These may be drawn as the arcs of a circle whose radius is 1½ *D*, or the same as that used for the arc *DEC*. Setting the trams to a length 1½ *D*, with points *A* and *D* as centers, strike arcs intersecting at the point *N*. Then with the point *N* as a center and the same radius, draw the arc *AD*. In a similar manner locate the point *S* and draw the arc *BC*. This completes the pattern, which, if suitable allowances are made for inside and outside plates, will answer for each of the six sections in the head. The arcs *AB*, *BC*, *CD* and *DA* represent the location of the rivet lines, and therefore the amount necessary for the laps should be added outside this to obtain a complete pattern.

superintendent of motive power's office of the C., B. & Q. Ry., lines east of the Missouri River, and a classification made of the conditions under which the failures occurred, with results as shown below. These failures include only ruptures:

	Number.	Percent.
1. Washing—Cooling	3	7.7
2. Washing—Using Nozzles	16	41.0
3. Washing—Filling	2	5.1
4. Washing—After filling	7	17.9
5. In shop or house, cold	7	17.9
6. In house, hot	2	5.2
7. Discovered arriving at terminal	2	5.2

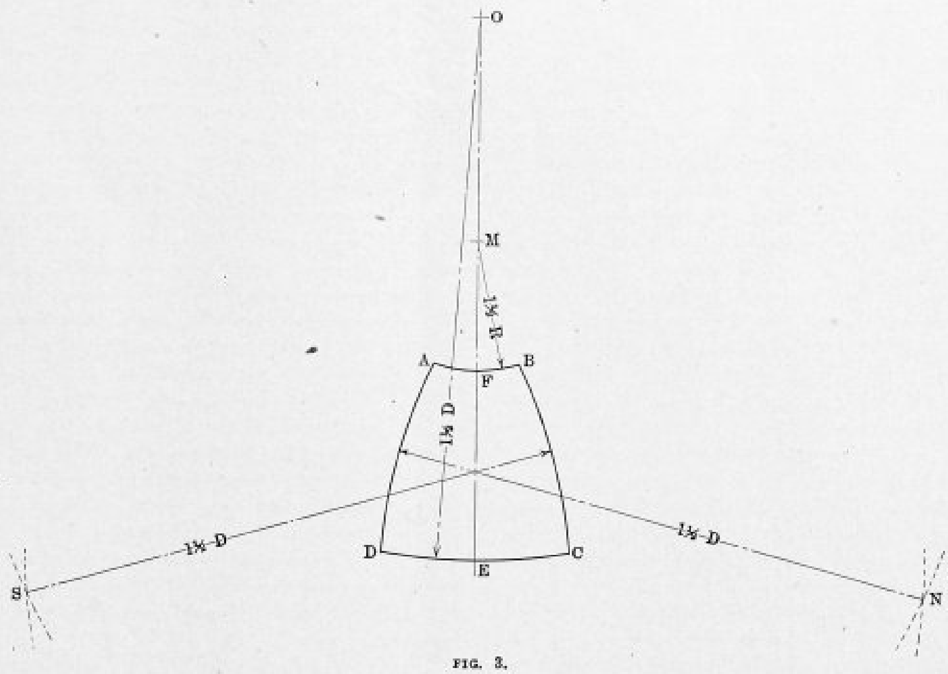


FIG. 3.

Failures and Specifications of Firebox Steel.*

BY M. H. WICKHORST.

In general, fire-box sheets fail in one of two ways; first, gradual failure—the sheet may have a good many small cracks which are mostly in a vertical direction. These cracks are thickest radiating out from the stay-bolts and frequently run from one stay-bolt to another in the same vertical row, but never between stay-bolts horizontally. These cracks are almost always on the fire side and at times extend through the thickness of the sheet, first going through next to the stay-bolts. Such sheets are almost always accompanied with more or less corrugation, and the cracked and corrugated condition is almost always confined to the lower half of the sheet. Secondly, sudden failure, or rupture; the sheets may fail by a single crack or rupture from a foot to several feet long. In bad cases, the crack may extend from the mud-ring to the crown sheet, but ordinarily the crack is confined to the lower half of the sheet, extending upward from the mud-ring or from a few inches above it, and is always near the middle of the side sheet longitudinally. Such sheets may show no corrugations and may show very little, if any, other defects. The failures of the first kind are of gradual formation, but those of the second class occur suddenly.

About two years ago a lot of records and papers concerning failures of fire-box sheets were gathered out of the files in the

* From a paper presented before the American Society for Testing Materials.

It will be noted from the above that **71.7 percent** occurred while the engine was being washed, this including 41 percent where nozzles were being used at the time; 17.9 percent occurred while the engine was cold under other circumstances, making a total of 89.6 percent for the failures while the engine was cold, and thus leaving 10.4 percent for such failures while the engine was hot, but it is not improbable that if the full details were at hand of the conditions attending the failures in these latter cases, that in some, or perhaps all, the records would show the engine had been cold. When washing the boilers, cold water had probably been used in all cases, and the above figures would seem to argue very strongly in favor of keeping the boiler continuously hot, and to use a method of washing out where the boiler does not get cold, say not below 150 degrees F.

TEMPERATURE TESTS OF FIRE-BOX STEEL.

If the metal is at any time heated to a red heat, or to near a red heat, failure from this cause would be the natural result, and in order to get some information concerning the temperatures actually attained by locomotive fire-box sheets, etc., under conditions of service, I arranged a method of test which consisted of boiling water in a can with thin sheet steel sides, with a bottom of ½-inch boiler plate, 4 inches in diameter, brazed to the sides. The boiler plate has a hole drilled into the side ⅛ inch in diameter extending to the middle of the plate. Heat is supplied by a specially constructed "pepper-box" burner, which gives a lot of gas flames over a flat, circular area of about four inches in diameter. The junction of the thermocouple is inserted into the hole in the plate to the middle, and the temperature is read on a galvanometer. Some preliminary results showed that if a fire-box sheet (including flue sheet) or the flues are free from scale or mud, the temperature of the metal probably does not at any time exceed the temperature of the water more than 50 degrees F., providing, of course, the circulation is sufficient to keep the water always in contact with the metal. Under the conditions of this experiment, with no scale or water on the plate, the metal attained a temperature of about 1,300 degrees F., and it may be noted that with ⅛-inch scale the metal attained a temperature of about 200 degrees above the temperature of the water, and with ¼ inch something over 400 degrees.

In a locomotive fire-box, the average temperature of the metal, if not protected by the water, would probably run between 2,000 degrees and 3,000 degrees F., and with scale ⅛ inch thick and with water in the boiler, the experiments indicate that the metal, including fire-box ends of the tubes, can readily attain a temperature of several hundred degrees above the temperature of the water, and it is not unlikely in some cases the metal actually attains a low red heat.

The action of the heat causes the water to flow upward between the tubes, and the counter current must flow downward between the tubes and shell of the boiler. The water evaporated from the side and other sheets of the fire-box is probably supplied mostly by a current flowing backward along the bottom of the barrel of the boiler. When this current reaches the flue sheet it divides, half going to each side water-leg, the current finally ending in the back water-leg where the two side currents meet. Of course, while this backward movement of the water is going on, the formation of steam also maintains an upward movement. This circulation carries all solid material that is light enough to move with the water into the back water-leg, where the circulation is probably least rapid. The heavier particles of mud and very light scale deposit on the back mud-ring up as high as the fire line, which is about 6 inches above the mud-ring. There is on the back mud-ring a cubic foot or so of quiet water space into which the mud and lime sludge is first carried, and when this space is filled up, deposits accumulate on the side mud-ring, and finally accumulations may occur on the front mud-ring. Critical examination of the mud deposits in a boiler after the water is drawn out is apt to show very little, if any, mud on the front mud-ring, and a depth of 6 or 8 inches on the back mud-ring, with more or less mud on the sides. No mud is apt to be present in the barrel of the boiler, as determined by a view through an inspection hole in the back flue sheet under the flues. Where there are also scale deposits, these will be found mostly in the barrel of the boiler and on the front mud-ring, as scale is too heavy to be carried round by the circulation, but the mud deposits will be found about as I have described above. Up to a height of 4 or 6 inches above the mud-ring, the mud accumulations remain below the fire line and cannot cause overheating of the sheets, but if more mud is allowed to accumulate in a boiler, it cannot be taken care of in this space. Such excess mud makes more or less trouble by keeping in the water circulation, depositing quickly on the tubes, crown sheet and particularly in the side and back water-legs as soon as active steam production stops, and in this way is apt to cause overheating of the side and back fire-box sheets by preventing free access of water.

If by means of a blow-off arrangement the back mud-ring can be kept free from mud, it would seem clear from the above considerations that the boiler can be kept free from excessive mud accumulations, since all the mud is carried by the circulation into the back mud-ring. A blow-off in the middle of the back water-leg, right above the mud-ring, removes mud from where it tends to accumulate most, but experience has shown the author that the mud is removed right around the blow-off cock, but on either side the accumulations are not disturbed. This led to trial of blow-off pipe laying on the full length of the back mud-ring and perforated with holes spaced about 4 or 6 inches apart. This arrangement has been tried somewhat extensively, and experience shows that mud can by this means be thoroughly removed from the boiler without the necessity of cooling down the boiler and washing.

Where water is treated with soda ash, the function of the soda ash is to cause the lime and magnesia salts to come down as a sludge instead of adhering as scale, and the circulation then carries the sludge into the back water-leg, where it can be successfully removed through a perforated blow-off pipe placed on the back mud-ring. By a combination of treatment of water with soda ash, the perforated blow-off pipe mentioned, and system of blowing out at terminals, engines can be made to run regularly 5,000 miles between wash-outs and without change of water other than obtained by the blowing out at terminals.

The water supplied into the boiler by means of an injector has a temperature ranging from 150 degrees to 180 degrees F., while the water in the boiler has a temperature with modern engines not much below 400 degrees F. Where water is injected into the boiler through an ordinary check valve placed on each side, this water drops to the bottom of the boiler unless there is active steam production going on to promote circulation.

If an engine is standing still, as, for instance, at a station, and the injector is on, the injected water seeks the lowest part of the boiler, which would be the water-legs around the fire-box. In order to know what was the extent of the segregation of such injected water, some tests were made with thermometers inserted into the side of the boiler. The apparatus consisted of a brass oil cup and extended about 4 inches into the water, and this held an ordinary chemical thermometer and a guard made of gas pipe, which protected the thermometer.

It will be noted that the oil cups were inserted into the left front corner of the outside fire-box sheet, one about on a level with the crown sheet, one about 7 inches above the mud-ring, and two applied in between. They were placed just a little ahead of the back tube sheet. One thermometer was also arranged in the delivery pipe just below the boiler check, in order to get the temperature of the water before entering the boiler.

The method of test was to get the water level at or near to the bottom of the glass, raise steam pressure to 195 pounds, as shown by the gage on the engine, and take temperature readings. The tests were made in the roundhouse, steam being produced by firing the engine with bituminous coal. They were intended to simulate the condition of an engine that has just arrived at a station, and whose injector is applied to pump water while the engine is standing still. Having obtained the water level and pressure as before mentioned, the injector was applied and the boiler filled to the top of the glass, temperature readings being taken every minute in most of the tests.

SPECIFICATIONS FOR FIRE-BOX STEEL.

The extreme limits for tensile strength of the various American specifications require fire-box steel to have 50,000 pounds per square inch as a minimum and 65,000 pounds as a maximum. In foreign specifications, the minimum limit seems frequently to run below 50,000 pounds per square inch. Formerly the American requirements for tensile strength were 50,000 pounds as a minimum and 60,000 pounds as a maximum. About fifteen years ago these limits were raised and were made 55,000 to 65,000 pounds, respectively, based apparently on the initiative of the Pennsylvania Railroad Company. Within the last few years, however, there has been a tendency to lower the limits, and the present limits of the American Railway Master Mechanics' Association are 52,000 to 62,000 pounds. It will be seen from what has been presented above that, under ordinary conditions of service, the locomotive boiler (including fire-box, and especially the lower parts) is frequently subjected to severe overheating, differences of temperature and severe and sudden changes of temperature around the lower parts of the fire-box and lower flues. It seems to be the result of experience that the harder grades of fire-box steel do not stand these abuses satisfactorily, but seem to develop cracks and ruptures, and very soft steel under similar conditions seems to stand these abuses a longer time before failure occurs, and, in fact, may become badly corrugated and distorted and still remain serviceable. It has been my experience that, as a general proposition, where fire-box sheets fail from single rupture without otherwise being badly cracked or corrugated, that the carbon runs toward .25 percent or higher and may run as high as .35 percent. On the other hand, the sheets which fail by corrugation and gradual cracking generally contain carbon between .12 to .25 percent. It seems, therefore, that as a general proposition, the softer grades of fire-box steel give better service than the harder grades, and the C., B. & Q. Ry. Co. has recently changed the requirements for fire-box steel to tensile strength running from 50,000 to 58,000 pounds per square inch, the former limits being from 55,000 to 65,000 pounds per square inch.

It seems clear to the author, however, that the problem of long life of fire-box steel is not so much a question of quality of steel, but is mostly up to the railroads. By suitable treatment of the water supplies, a proper arrangement for delivering feed-water into the boiler, and proper methods of caring for boilers in roundhouses and elsewhere, long life can be expected with any grade of fire-box steel, and most of the complaints of poor steel are then apt to disappear.

CONCLUSION.

In conclusion, the author suggests that long life of fire-box steel is to be obtained: First, by suitable treatment of feed-water; generally plain soda ash treatment to destroy all sulphate of calcium will answer the purpose, but where the water is very hard, softening with lime will also be desirable; second, by avoiding considerable and sudden variations of temperature, due to cold feed-water dropping to the bottom of the boiler when active steam production is not going on. Some feed-water arrangement should be used which will not allow the water to thus segregate; third, by keeping the boiler continuously hot and avoiding wash-outs, especially with cold water; a blow-off pipe on the back mud-ring connected to a blow-off cock in the back corner in conjunction with a system of blowing will keep the boiler free from all accumulations if the water has been suitably treated. The blowing out is also necessary to keep the concentration of the water below the foaming point, say 200 parts per 100,000.

If the above are done, probably the quality of fire-box steel is of secondary importance; but the author suggests that the quality of steel called for in the specifications of the American Railway Master Mechanics' Association, tensile strength of 52,000 to 62,000 pounds, will probably in general be most satisfactory.

WATER-TUBE BOILERS for locomotives have not proved successful in most cases. There are, however, fifteen such locomotives fitted with Brotan water-tube boilers, which are in operation on the Austrian State Railways. It is claimed that their performance has been so satisfactory that nineteen more locomotives are to be built with the same type of boiler.

The Ageing of Mild Steel.

A few months ago, in a paper presented before the Iron and Steel Institute, Mr. C. E. Stromeyer, chief of the Manchester (England) Steam Users' Association (see THE BOILER MAKER of August, 1907, page 248), mentions several failures of steel plates and structural shapes, which seem to indicate that some qualities of mild steel might have the property of changing their nature with age. In order to decide this point Mr. Stromeyer carried out numerous tests, the results of which, in a great measure, justified his opinion. Since that paper was presented, additional tests have been carried out, the results of which have been embodied in a second paper and presented before the Institute at its September, 1907, meeting.

The additional tests included the following: One set of samples of plate with sheared edges, which had been laid aside for nine weeks and then stored for twenty-three weeks in ice in a cold chamber at a temperature of 16 degrees below zero, after which they were taken to the boiler works and each sample, while still coated with ice, was bent with a sledge hammer until it cracked; a second set of samples with sheared edges, which had been lying in a storeroom for thirty-two weeks, were bent in the same way at ordinary temperatures; four sets of samples, which had been annealed, planed and nicked on their edges, were also bent till the nicks cracked, one lot having been bent immediately after nicking, another after waiting twelve weeks, and the present lot after waiting thirty-two weeks. Five other lots had been subsequently annealed, planed and nicked on the edge, one of which was bent at once, one after boiling for 15 minutes, and one after being placed in the steam space of a Lancashire boiler with a working pressure of 120 pounds and kept there for seventeen weeks. One had been placed in a store for seventeen weeks, and another had been taken to the cold chamber within a few hours after being nicked and left there seventeen weeks. All of these samples were bent at the same time at ordinary summer temperature.

When the samples were bent, the ductility of the metal was measured, both by the increase in length of the outer edge of the plate, and also by the comparative length of the radius of curvature of the inner surface.

The results of these tests revealed a very mild deterioration in the steel with time. A few exceptions were noted, but in these cases the steels were highly phosphoric, which might account for their erratic behavior. With the majority of such samples there was a marked or medium falling off in ductility. Sometimes this was very sudden, the full effect being produced within twelve weeks, while with other steels the ageing process seems to have been a gradual one and could not be said to have been completed after waiting thirty-two weeks. In one instance a sample was found to be much more brittle after waiting fifteen years than when it was six months old.

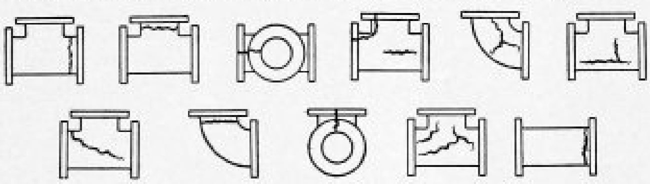
The ageing process is accelerated by exposure to heat. This was very apparent from the fact that samples which were boiled only 15 minutes showed practically the same results as those which were kept thirty-two weeks. Not content with the knowledge that boiling for a few minutes has the same effect as placing a sample aside for a few months or weeks, it was decided to place other samples in the steam space of a Lancashire boiler working at 120 pounds per square inch. These samples were allowed to remain for seventeen weeks, but as the boiler was not used continuously, the true steaming period was probably somewhat shorter. The effect of this steaming was practically the same as that obtained by boiling for a short time. It was also noticed that long-continued steaming causes more brittleness in the neighborhood of an injury, such as a nick or crack, than by merely boiling for 15 minutes.

The samples which were placed for seventeen weeks in cold storage, with one or two exceptions, preserved 30 percent more elongation than those which had simply been kept under ordinary conditions, and 50 percent more than those which had been boiled. It is thus evident that cold storage does less to harm mild steel than steaming.

As the experiments were carried out on a heterogeneous lot of steels, some being from failed boilers, and others known to contain an excess percentage of silicon, phosphorus or sulphur, they go far towards dispelling the belief that prolonged and intense cold may cause some steels to become brittle. The reverse is rather the case, for, according to these experiments, prolonged exposure to heat, and not to cold, tends to make mild steel brittle. For fear that these remarks may lead to a misunderstanding, it is desired to mention here that there is nothing in these experiments to show whether mild steel is more or less brittle when cold than when hot, and that on this point one has to be guided by experience, according to which steel rails are known to snap more frequently in cold weather than in warm, and that boilers have practically never failed by cracking when in use. Explosions are usually due to other causes.

The Bursting Point of Flanged Fittings.

About four years ago the Crane Company, of Chicago, Ill., entered upon a series of tests to determine the average point at which flanged fittings of various sizes would burst under hydraulic pressure. The company had, of course, access to all rules laid down in engineering text books, but most of these rules had been made from experiments on cylinders and not on fittings, so it was deemed advisable to establish by actual



MANNER IN WHICH THE FITTINGS FAILED.

destruction the ultimate strength of fittings of various kinds and sizes. All tests were made by bolting blind flanges to the openings of the fittings and then admitting water through a small opening in one flange.

At the time the fittings were cast, test bars were run out of the same ladle, so that specimens of exactly the same material would be available for testing the quality of the material. These test bars were found to run very uniformly, the variation in thirty heats being only 20 percent between the highest and lowest bar, while the average variation was only about 5 percent. As test bars cast from the same ladle and the same mold at the same time will show a variation in strength, it was concluded to accept the average strength of all bars made for these tests as the strength of the metal in the fittings.

The bars averaged in tensile strength ferrosteel 33,000 pounds per square inch, and cast iron 22,000 pounds per square inch. The average results of the destructive tests on the fittings gave for ferrosteel 2,066 pounds per fitting and for cast iron 1,263 pounds per fitting. Therefore, the ferrosteel fittings showed stronger than cast iron by 63.7 percent, while ferrosteel bars showed stronger than cast iron by 50 percent.

For the purpose of more accurate comparison between the bursting point of fittings and the tensile strength of test bars cast at the same time, a few examples of 12-inch extra heavy tees are given. The average results show that the ferrosteel fittings burst at 2,033 pounds and the cast iron at 1,466, while the tensile strength of the test bars was 33,005 pounds per square inch for ferrosteel and 22,226 for cast iron.

Using these destructive tests as a basis, a rule was formulated which when applied to flanged fittings can be used to determine the thickness of metal for a given pressure, or the metal being known, can be used to determine the pressure required to rupture it. The rules proposed are as follows:

Rule No. 1.—Thickness of metal not being known, to determine the bursting point—

$$\frac{T}{D} \times S = B.$$

where T = thickness of metal.
D = inside diameter.
S = 65 percent of the tensile strength up to 12 inches diameter, larger sizes use 60 percent.
B = bursting point.

For the working pressure, divide the result by a factor of safety of from 4 to 8.

Rule No. 2.—Bursting point being given to determine the thickness of metal—

$$T = \frac{B \times D}{S}$$

These rules work out fairly well for all cases, but it is not to be expected that they will apply absolutely to every individual fitting, as there are always some irregularities in castings and the final strength of the metal in the fittings is influenced by many things, such as the condition of the sand, fluidity of the iron, time of shaking out, etc.

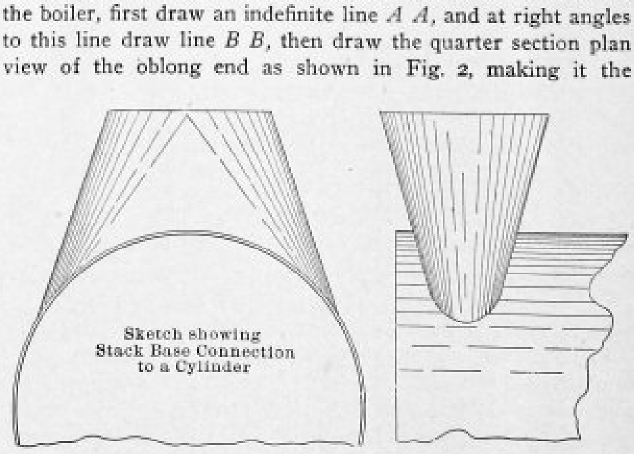
The nature of the fractures in the different fittings is clearly shown in the illustration.

The Development of an Irregular Connection by Triangulation.

BY J. E. BOSSINGHAM.

This problem is a good exercise for the student on the drawing board, also it is a practical method of laying out a smokestack base, connecting directly on to a return tube or locomotive type of boiler. The "sketch showing stack base connection to a cylinder" gives a good idea of its practicability. You will notice that Fig. 1 is only one-half of the elevation, and that Fig. 2 is only one-quarter of the plan view; this is all that is necessary in the development, as all the other parts are similar, thus reducing the working lines and saving a large amount of space and unnecessary work.

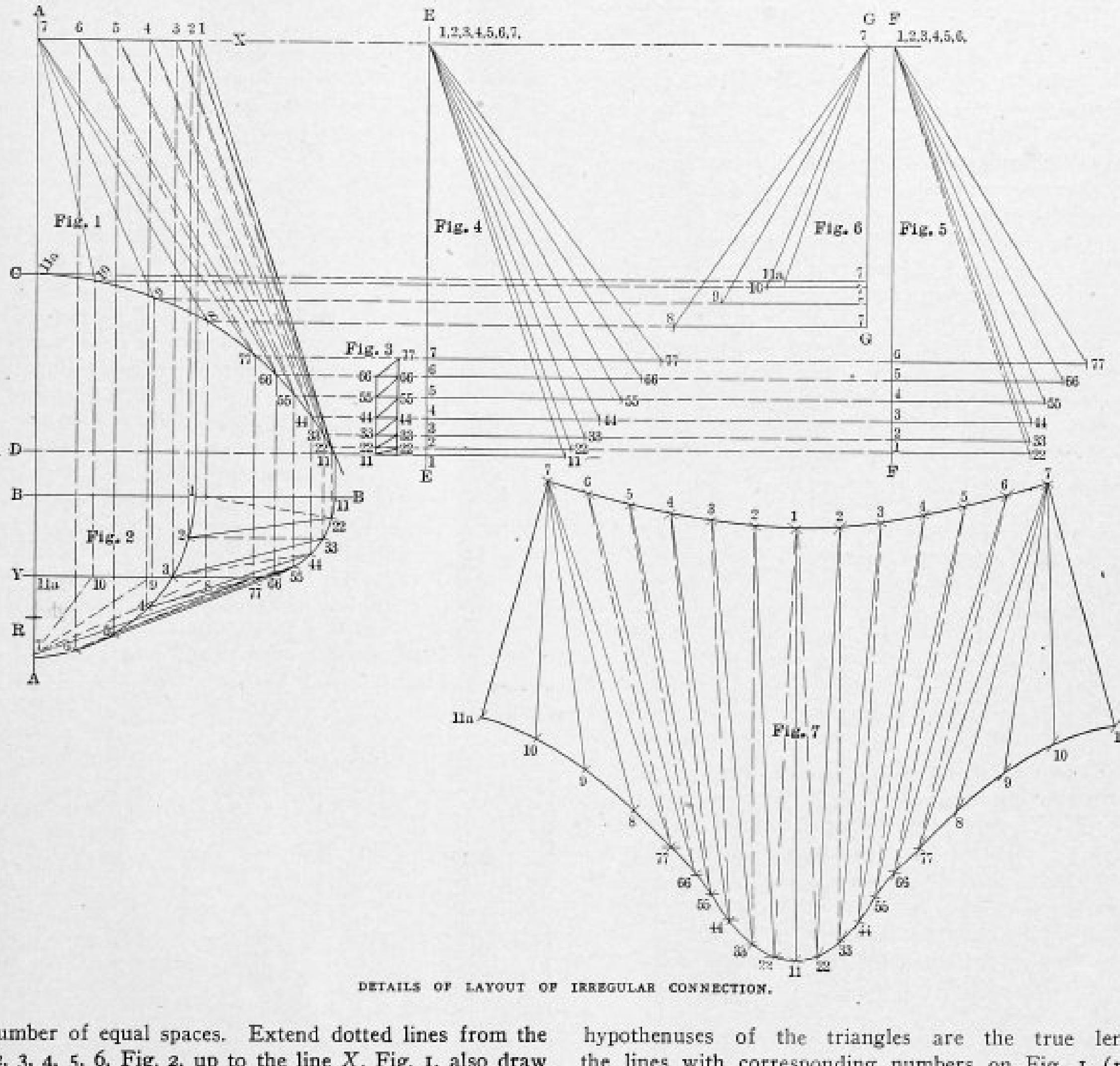
Having determined the smoke outlet required for the size of the boiler, first draw an indefinite line *A A*, and at right angles to this line draw line *B B*, then draw the quarter section plan view of the oblong end as shown in Fig. 2, making it the



SKETCH OF THE COMPLETED CONNECTION.

same area as one-quarter of the area of the circle. (The oblong is the size of the opening in the cylinder on line *D*, looking up or down through elevation, Fig. 1.) Then with *R* as a center, draw the arc *C* of indefinite length. Make the distance 7 to 11*a*, Fig. 1, any required height, and at point 7 extend an indefinite line *X* at right angles to *A A*, from the points 1 and 11, Fig. 2, on line *B B* extend dotted lines until they intersect arc *C*, also extend a line from 7, Fig. 2, up to the line *X*. From point 1 draw a line to point 11, Fig. 1. This gives you the outline of one-half of the elevation Fig 1. Now space the quarter circles of the plan view, Fig. 2, into the perpendicular lines, making the distance between them equal to the distance from 11 to 22, Fig. 2. Then draw lines from 11 to 22, 22 to 33, 33 to 44, 44 to 55, 55 to 66 and 66 to 77, the length of the lines is the true spacing in laying out the development of Fig. 7.

To secure the triangles in Fig. 4, first erect the perpendicular line *E E*. Set off on line 11 from line *E E* a distance equal to 1-11, Fig. 2. Likewise take from Fig. 2 the distances 2 to 22, 3 to 33, 4 to 44, 5 to 55, 6 to 66 and 7 to 77 and set them off from line *E E*. Then the lines drawn from the intersection of *E E* and *X* to the several points set off from the



DETAILS OF LAYOUT OF IRREGULAR CONNECTION.

same number of equal spaces. Extend dotted lines from the points 2, 3, 4, 5, 6, Fig. 2, up to the line *X*, Fig. 1, also draw dotted lines from 22, 33, 44, 55, 66 and 77, Fig. 2, up to the arc *C*, Fig. 1. From the point 77, Fig. 1, space off on arc *C* equal spaces as at points 8, 9, 10, 11*a*, and from these points drop dotted lines down to line *Y*, Fig. 2.

On the plan view, Fig. 2, connect the points 2 to 22, 3 to 33, 4 to 44, 5 to 55, 6 to 66 and 7 to 77, also 7 to 8, 7 to 9, 7 to 10. The lines 1 to 11 and 7 to 11*a* have already been drawn. These lines constitute the base lines for the direct triangles as shown in Figs. 4 and 6. Then from point 1, Fig. 2, draw a dotted line to 22, also from 2 to 33, 3 to 44, 4 to 55, 5 to 66 and 6 to 77, these make the base lines for the diagonal triangles Fig. 5.

To secure the actual distance to step off on the layout of the intersection on the arc *C*, it is necessary to draw another set of triangles, as shown in Fig. 3. To secure the different sets of triangles, extend lines of indefinite length at right angles to line *A A* from the points 11, 22, 33, 44, 55, 66, 77, 8, 9, 10, 11*a*. To complete the triangles, Fig. 3, first draw two hypothenuses of the triangles are the true lengths of the lines with corresponding numbers on Fig. 1 (note, the lines on the elevation of Fig. 1 are not the true lengths. They are only filled in to show more clearly the different points of the plan, Fig. 2).

To secure the true length of the dotted lines of Fig. 1, proceed in same manner. Erect the line *F F*, Fig. 5, and with distances 1 to 22, 2 to 33, 3 to 44, 4 to 55, 5 to 66 and 6 to 77 from Fig. 2, set off on lines 22, 33, 44, 55, 66 and 77, and with these points connected with the intersection of line *F F* on *X* you have the true length of the dotted lines on Fig. 1.

The lengths of lines 7 to 8, 8 to 9, 9 to 10 and 10 to 11*a*, Fig. 6, are secured from Fig. 2 and set off in the same manner as in Figs. 4 and 5.

To develop the layout, Fig. 7, first erect the perpendicular line 1 to 11 equal to 1-11, Fig. 4. Draw a short arc equal to 11-22, Fig. 3, from 11, Fig. 7. Then set off from 1, Fig. 7, a distance equal to 1-22, Fig. 5. Draw another short arc from 1, Fig. 7, equal to the space 1-2, Fig. 2, and with a distance equal to 2-22, Fig. 4, lay off an arc from 22, Fig. 7, cutting the short arc previously drawn at point 2, Fig. 7. Proceed in like manner on both sides until you have laid down all the lines up to 7-77, then with a short arc from 77, Fig 7, equal to 77-8, Fig. 1, set off from 7, Fig. 7, a distance equal to 7-8, Fig. 6, cutting the short arc at point 8, Fig. 7. Proceed in the same manner with all the triangles of Fig. 6, using the same spacing on points 8 to 9, 9 to 10, 10 to 11*a*, as in Fig. 1.

Draw straight lines from points 7 to 11*a*, and a smooth curve through all other points and you have one-half the development of the irregular surface as shown in the sketch. All allowances must be made for material, laps and flanges.

Proportions of Steam Boilers.

BY JOHN COOK.

The measure of efficiency of a steam boiler is the number of pounds of water evaporated per hour per pound of combustible, the evaporation being reduced to the standard of "from and at 212 degrees F." By evaporation from and at 212 degrees F. is meant the equivalent evaporation of feed-water at a temperature of 212 degrees F. into steam at atmospheric pressure.

The capacity of a boiler is expressed in the number of boiler horsepower developed. A boiler horsepower is the term given to the evaporation of 30 pounds of water per hour from water at 100 degrees F. into steam at 70 pounds pressure, or the evaporation of 34½ pounds per hour from and at 212 degrees F.

GRATE AREA.

Assuming a 40-horsepower stationary tubular boiler, the problem is to find the required proportions of heating surface, grate surface, as well as the size of tubes, thickness of shell, etc. As each boiler horsepower is equivalent to the evaporation of 34½ pounds of water per hour, then the equivalent evaporation per hour of a 40-horsepower boiler would be $34.5 \times 40 = 1{,}380$ pounds of water per hour. One pound of average coal will, under favorable conditions, evaporate from 8 to 10 pounds of water per hour. Assuming for an average value 9.2, then the number of pounds of coal required per hour would be $\frac{1{,}380}{9.2} = 150$. With good combustion 12 pounds of coal would be consumed per square foot of grate surface per hour. As we must burn 150 pounds of coal per hour, the grate surface required would be $\frac{150}{12} = 12\frac{1}{2}$ square feet.

NUMBER AND SIZE OF TUBES.

The area through the tubes should be at least 1/7 of the grate area. The grate area has been found to be 12½ square feet or $12\frac{1}{2} \times 144$ square inches. Therefore, the area through the tubes should be $\frac{12\frac{1}{2} \times 144}{7} = 257$ square inches. A 3½-inch tube is the most common size used in a boiler of this size, and so 3½ inches will be taken as the outside diameter of the tubes. The tubes are approximately ⅛-inch thick, and therefore the inside diameter is 3¼ inches. The sectional area of a tube 3¼ inches inside diameter is $.7854 \times (3\frac{1}{4})^2 = 8.295$ square inches. Dividing 257, the total tube area, by 8.295, the area of one tube, we find that thirty tubes are necessary.

DIAMETER OF SHELL.

Having found the number of tubes, we must find the diameter of shell to correspond. Allow ⅓ the diameter of shell above the tubes and a space for a large hand-hole, say 6 by 8 inches below the tubes, and lay out the tubes so that there will be 1 inch vertical space between the rows with two inches in the center to allow for a good circulation. The least diameter of shell that can be used under these conditions is 42 inches. With a 42-inch shell, by placing the center of the top row of tubes 3½ inches above the center line there will be a space of 2½ inches from the shell to the third row of tubes and a height of 17½ inches above the top row of tubes.

LENGTH OF BOILER.

Having determined the diameter of shell and the number and size of tubes, the next thing is to get the length required for a 40-horsepower boiler. The boiler must be made of such length that there will be sufficient heating surface. A fair ratio of heating surface to grate area is from 40 to 45. Assuming, in this case, 42 square feet for every square foot of grate area, then there should be $42 \times 12\frac{1}{2}$ or 525 square feet of heating surface in the boiler. Now, determine the amount of heating surface per foot of length in a 42-inch shell containing thirty 3½-inch tubes. A 3½-inch tube contains 132 square inches of heating surface per foot of length. $132 \times 30 = 3{,}960$ square inches, or dividing by 144, 27½ square feet of heating surface per foot of length for the thirty tubes. Two-thirds of the circumference of the shell is reckoned as heating surface. If the shell is 42 inches inside diameter, the mean diameter will be 42 plus the thickness of metal. In general practice this size boiler is made of quarter-inch plate, but as we wish a first-class job we will use 5/16-inch steel. Therefore, the circumference of a shell 42 5/16 inches in diameter is 132 + inches, and two-thirds of this, or the amount which is reckoned as heating surface, is 88 inches; $88 \times 12 = 1{,}056$ square inches of heating surface on the shell per foot of length; 1,056 square inches equals a little over 7 square feet. Therefore, adding 7 square feet of heating surface per foot of length of the shell to the 27½ square feet of heating surface per foot of length of the tubes, we have 34½ square feet as the total heating surface per foot of length of the boiler. This could be slightly increased by adding a few feet more for two-thirds the area of the back head, minus the area of the tubes, but in this calculation this area may be omitted, as it is small in comparison.

Now, we have found that the boiler must have 525 square feet of heating surface, and that there are 34½ square feet of heating surface in each foot of length of the boiler. Therefore, dividing 525 by 34½ we get 15.2 feet, or say 15 feet for the length of the boiler. This gives us about 13 square feet of heating surface to the horsepower. In general, manufacturers have their own ideas as to the amount of heating surface which should be allowed per horsepower, the values ranging from 10 to 15 square feet to the horsepower.

RIVETED JOINTS.

We have now determined the principal dimensions of the boiler, such as the length, diameter, number and size of tubes, area of grate and heating surface. We can now proceed with the details of the riveted joints and the bracing. In order to get the proper size for the rivets, use the rule given on page 4 of Boiler Rules and Formulas, compiled for the Master Steam Boiler Makers' Association. This rule is as follows: "Extract the square root of the product of the thickness of the plate in decimal parts of an inch and the following constants. Commercial sizes of rivets 1/16 smaller than the hole to be used."

The constant should equal 2.25 when the joint is to be a double-riveted lap joint between plates up to and including ½ inch in thickness. As we have decided to use a 5/16-inch plate and a double-riveted lap joint, this constant may be used. The square root of $.3125 \times 2.25 = .838$ inch or 13/16 inch; this is the size of the rivet hole; the rivet should be 1/16 inch smaller, or ¾ inch.

The pitch of rivets may be found as follows:

$$P = D + \frac{A \times S \times N}{t \times T}$$

where P = pitch in inches.
A = area of one rivet in square inches.
S = shearing strength of rivets in pounds per square inch.
N = number of rows of rivets in joint.
t = thickness of plate in inches.
T = tensile strength of plates in pounds per square inch.
D = diameter of rivet hole in inches.

Multiplying the area of the rivet hole, .51849 by 38,000, the shearing strength of the rivets, we get 19,703. Multiplying this by 2, the number of rows of rivets in a double-riveted lap joint, we get 39,406. The thickness of the plate .3125 times the tensile strength of plate, 60,000, equals 18,750. $\frac{39,406}{18,750} = 2.1001$. Adding the diameter of the rivet, .8125, we get 2.9126 inches, or about 2⅞ inches as the pitch of rivets for the longitudinal seam.

For the single-riveted circular seams, carry out the same computation, the only difference being that there is only one row of rivets, and therefore 19,703 should not be multiplied by two. This gives the pitch as 2¼ inches.

After determining the diameter and pitch of rivets, figure out the strength of the riveted joint. The strength of the solid plate for one pitch of rivets will be 2⅞ × 5/16 × 60,000 = 53,906 pounds. The strength of the net section of plate left after punching or drilling the holes will be (2⅞ — 13/16) × 5/16 × 60,000 = 38,484 pounds. The shearing strength of the rivets will be 38,000 × .51849 (area of one rivet) × 2 = 39,405 pounds. Therefore, the net section of the plate is weaker than the rivets, and the percentage strength of the joint will be determined by the percentage strength of the net section of plate

$$\frac{38,484}{53,906} \times 100 = 71.409 \text{ percent.}$$

SAFE WORKING PRESSURE.

The allowable working pressure may now be determined for the boiler as follows: Multiply the tensile strength of the material, 60,000, by the thickness of shell in inches, .3125, by the percentage strength of the joint, 714, and divide by the radius, 21, multiplied by the factor of safety, 5. Carrying out this computation, we find the safe working pressure to be a little over 127 pounds per square inch.

BRACING.

Assuming that the heads are to be 7/16 inch thick, it is necessary to determine the number and spacing of the braces necessary to stay the segment of the heads above the tubes against a steam pressure of 127 pounds per square inch. The center of the top row of tubes is 3½ inches above the center line of the head. It may be assumed that the top row of tubes will securely brace the head to a width of 2 inches above the tubes and also that the flange of the head will securely brace a strip 3 inches wide all around the edge. There would then be left to be stayed a segment 10¾ inches high of a circle 36 inches in diameter, as shown in the diagram. To get the area of this segment, find the area of a circle 36 inches in diameter. This equals 1,017.88 square inches. Dividing this by 2 we get 508.94 square inches as the area of the semi-circle. Subtract from this the area of the rectangular portion above the center line, which is braced by the top row of tubes. This portion is 33 inches long by 7¼ inches wide, making a total of 238.25 square inches; 508.94 — 238.25 = 270.69 square inches, area of segment. The pressure on this area will be 271 × 127 = 34,417 pounds. Allowing 6,000 pounds to be carried by each brace, we have $\frac{34,417}{6,000} = 5.7$ braces. Therefore it will take six braces to securely brace the head.

THE STACK.

In laying out the front extension and stack for a 40-H. P. boiler the width of the extension and also of the stack saddle will depend on whether the boiler has a half-arch front. If so, the extension will project over, and a wide extension would interfere with firing. An extension 16 inches wide would probably be satisfactory, and on this a stack saddle 12 inches wide could be fitted.

The writer's plan is always to allow one-eighth more area in the up-take than the area of the tubes and one-fourth more area in the stack than in the tubes. The area of one tube 3½ inches in diameter is 8.295 square inches, and as there are thirty tubes the total area is 248.85 square inches. Therefore,

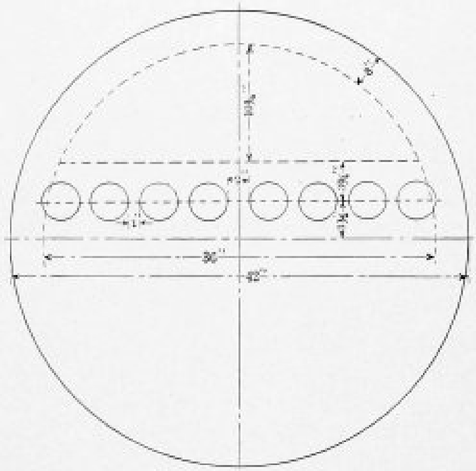


DIAGRAM OF BOILER HEAD SHOWING SEGMENT TO BE BRACED.

the area of the up-take should be 1⅛ × 248.85 = 279.956 square inches. As the opening for the up-take is to be rectangular in shape, 12 inches wide, with circular ends, it is necessary to determine the length of the opening in order that its area shall be 279.956 square inches. The area of the circular ends, which are 12 inches in diameter, equals $(12)^2 \times .7854$, or 113.0976 square inches. Subtracting this from 279.956, total area, leaves 166.8584 square inches, the area of the rectangular part of the opening. As the width of this is 12 inches, the length will be $\frac{166.8584}{12}$, or about 14 inches. Therefore, the up-take or saddle will be 12 by 26 inches.

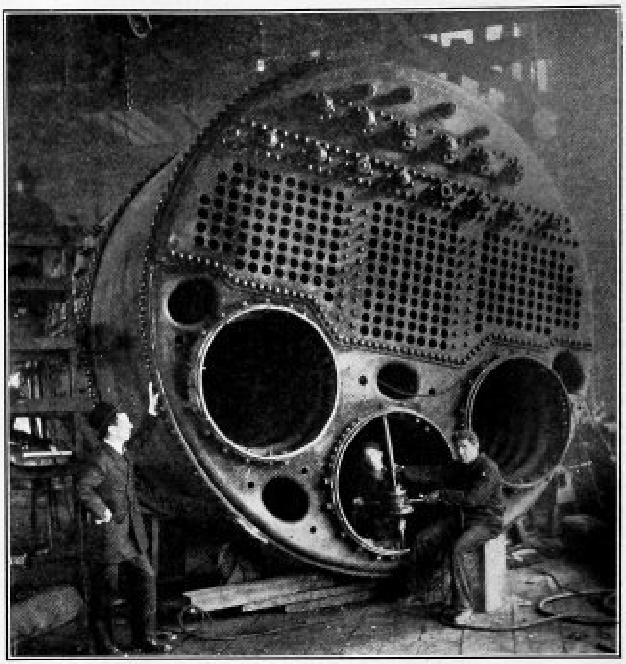
As stated before, the area of the stack is to be one-quarter more than the tube area, or 1¼ × 248.85 = 311.0675 square inches. Looking up this value in a table of areas of circles, we find that the nearest diameter corresponding is 20 inches. Therefore the diameter of the stack will be 20 inches.

Now for the height of the stack. There are many complicated ways in which this might be figured, but it would take a "Philadelphia lawyer" or a first-class mathematician to work them out. A simple rule used for many years by the author and, so far as he knows, original with him, is as follows: Take the value in square inches which has been found for the tube area (in this case 248.85 square inches), move the decimal point one place to the right, and extract the square root of the result. The result will be the height of the stack in feet. Moving the decimal point one place to the right in the value for the tube area of the 40-H. P. boiler gives 2488.5, and the square root of this is 49.1. Therefore the height of the stack should be 49 feet. This is the height from the top of stack to the top of grates, and as the grate should be at least 3 feet below the bottom of the boiler, the boiler itself being 3 feet 6 inches in diameter, the whole length of the stack will be only 42 feet 6 inches.

The writer is aware that this stack is about 12 feet higher and 2 inches greater in diameter than the standard stacks sent out for this size boiler, but there are generally complaints after the boiler is in operation that there is not enough draft, or that the boiler is a slow steamer, and it is all due to the fault of not having stack enough. There are probably but few shops that have not had the job of lengthening stacks where, if there had been sufficient area in the stack, it would have worked all right. The writer has known of stacks which had more than 100 square inches less area than the tubes. It must be understood that the whole area of the stack is not efficient draft area. The smoke arising will cling to the sides and form an eddy from 1 to 2 inches deep on the surface of the stack, so that in a 20-inch stack the diameter of the efficient draft area is really only 16 or 18 inches. This is the reason why the author always allows one-quarter more area in the stack than in the tubes.

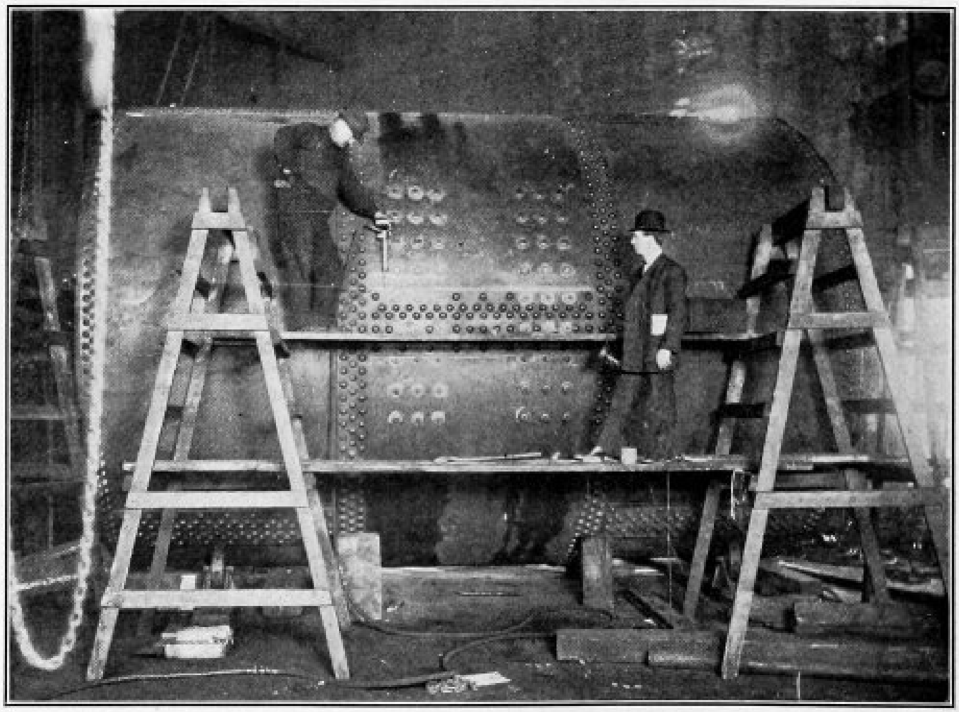
Boilers for the U. S. S. Yankee.

It may not seem to be a very unusual or remarkable accomplishment to the boiler makers in a large, modern, up-to-date contract shop to build three double-ended boilers each 13 feet 10 inches diameter and 20 feet long, with six furnaces and separate combustion chambers, but to carry out this work successfully and rapidly in a navy yard, where the equipment of the boiler shop is suitable only for repair work and small jobs, is a feat worth noting. The boilers for the United States ship *Yankee*, photographs and drawings of which are shown herewith, were built at the Charlestown (Mass.) Navy Yard, under the supervision of Mr. J. R. Truckses, master boiler maker. In this yard the boiler shop is small, and as yet has not been equipped with modern machinery and cranes for handling large and heavy jobs of boiler construction. An endeavor is now being made, however, by the head of the Department of Steam Engineering, Commander George E.



END VIEW OF THE BOILER, SHOWING METHOD OF DRILLING FURNACES.

Bird, U. S. N., to secure an appropriation for the enlargement of the boiler shop at this yard and the installation of electric cranes and more modern machinery. Certainly the work done at this yard with the available facilities speaks well for the ability and ingenuity of the master boiler maker, and should be a good argument to be used by the chief engineer in



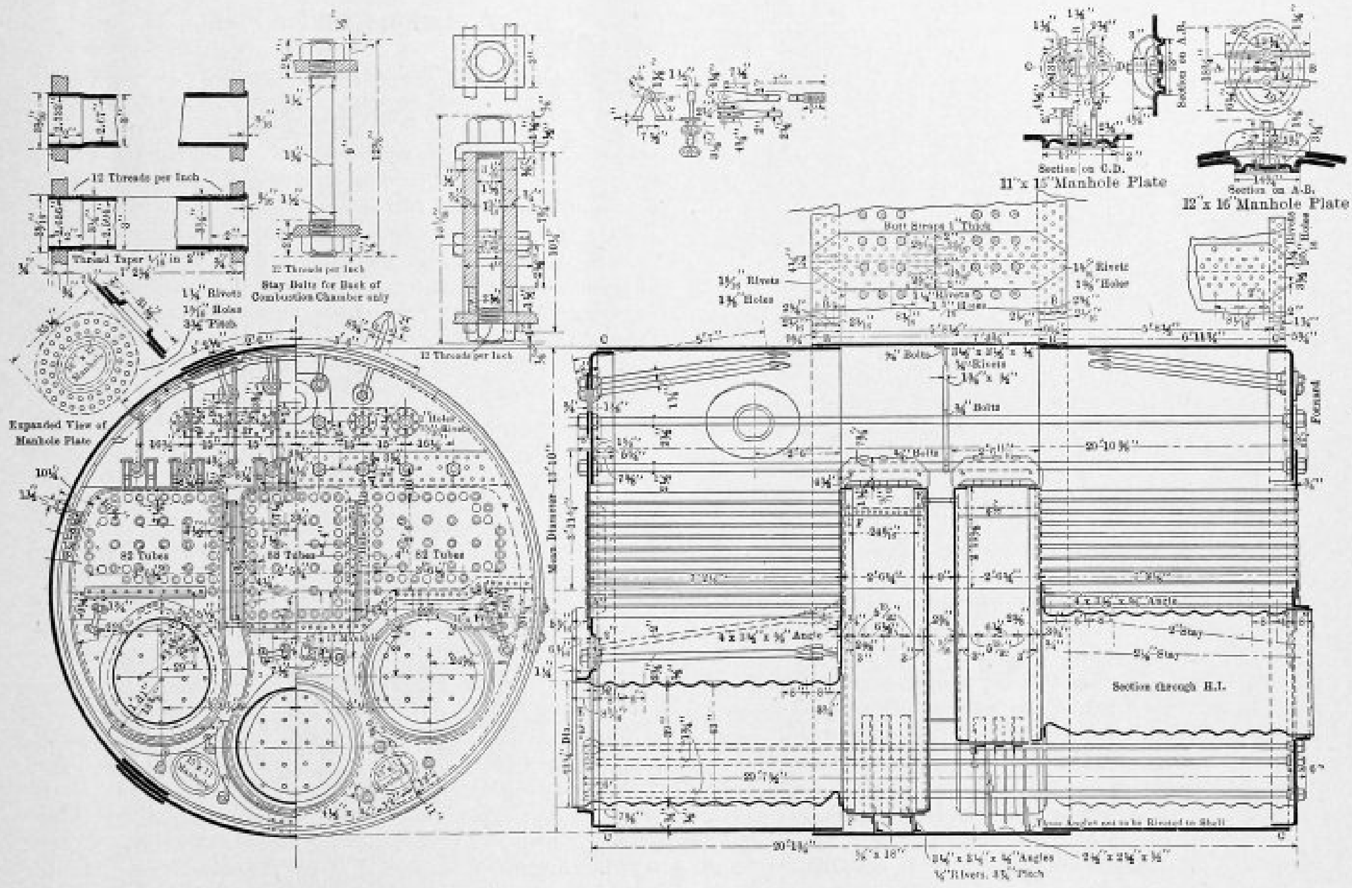
SIDE VIEW OF THE BOILER, SHOWING DETAILS OF RIVETING.

his request for an appropriation from Congress to modernize this plant.

The boilers of the *Yankee* are the largest ever constructed in a government navy yard, and have been the source of considerable favorable comment from outside manufacturers who have been fortunate enough to witness their construction. The boilers are 13 feet 10 inches mean diameter by 20 feet 1¾ inches long outside the heads. They are to be operated at a steam pressure of 170 pounds per square inch, and will weigh when completed 68 tons each. Each boiler has six corrugated furnaces with separate combustion chambers and 504 3-inch tubes. The grates are each 6 feet 10 inches long by 3 feet 4½ inches wide, making a total grate area of 138 square feet. There is a total heating surface in each boiler of 3526.97 square feet, divided as follows: Heating surface of tubes,

ened with 1 5/16-inch rivets in 1⅜-inch holes, spaced 4⅛ inches between centers. The percentage strength of plate at these joints is 66.66, and of the rivets 68.6.

The boiler heads are all flanged inwards and joined to the shell with double riveted lap seams fastened by 1¼-inch rivets in 1 5/16-inch holes, spaced 3½ inches between centers. The percentage strength of the plate in the joint is 62.5, and the percentage strength of the rivets 70.15. Each head is in three sections, the tube plate, which is ¾ inch thick, the furnace plate 1⅛ inch thick and the upper portion, which is in the steam space of the boiler, also 1⅛ inches thick. The upper plate is joined to the tube plate with a triple riveted lap joint, fastened by 1¼-inch rivets in 1 5/16-inch holes, spaced 3½ inches between centers, the percentage strength of the plate being 62.5, and of the rivets 70.15. The tube plate is joined to the



LONGITUDINAL AND SECTIONAL VIEWS OF YANKEE BOILER, WITH DETAILS OF TUBES, STAYS, RIVETED JOINTS, ETC.

2840.98 square feet; heating surface of furnaces, 242.25 square feet; heating surface of combustion chambers, 443.74 square feet. The ratio of heating surface to grate area is therefore 25.55. The area over the bridge wall is 3.11 square feet, and its ratio to the grate area 1 to 7.42.

The shell of the boiler is constructed of three courses of three plates each, the middle course being the outside course. The plate is open-hearth mild steel of 60,000 pounds tensile strength 1¼ inches thick. The longitudinal seams of the shell are triple riveted butt joints, the butt straps being of plate 1 inch thick, fastened with 1¼-inch rivets in 1 5/16-inch holes, pitched 8 1/16 inches between centers. The inner rows are 2 5/16 inches apart and the outer ones 3 5/16 inches. The percentage strength of plate at the joint is 83.72, and the percentage strength of rivets 93.27. All rivets in the boiler are of mild steel of 58,000 pounds per square inch tensile strength and about 48,000 pounds per square inch shearing strength. The girth seams of the shell are triple riveted lap joints, fast-

furnace plate by a single riveted lap joint fastened with 1 3/16-inch rivets in 1¼-inch holes, spaced 2⅝ inches between centers, the percentage strength of the plate being 52.3 and of the rivets 51.6. The furnace holes are all flanged outward, and, of course, the manhole openings are flanged inwards.

The corrugated furnaces are each 7 feet 8 3/16 inches long and 43 inches outside diameter. The inside diameter is 39 inches, and the thickness of the plate ½ inch.

The combustion chambers are all 2 feet 6¼ inches wide, the tube plate being ¾ inch thick and the wrapper and back plates 9/16 inch thick. The bottom of each chamber is stayed by three 3½ by 3½ by ½-inch angles riveted to the combustion chamber, but not to the shell plate. The tube plates just over the furnaces, but below the nests of tubes, are stayed by horizontal angle-bars 4 by 3½ by ⅝ inches, and also by diagonal stays 2 inches in diameter, fastened to the tube plate by means of crowfeet. The sides and backs of the combustion chambers are stayed by ordinary stay-bolts, 1½ inches in diameter at the threaded portion at the end which is reduced to $1\frac{1}{4}$ inches at the plain portion in the middle. These stay-bolts are spaced $6\frac{1}{2}$ by $8\frac{1}{4}$ inches on the sides and $7\frac{1}{2}$ by $7\frac{1}{2}$ inches on the back. All the bolts are nutted inside and out. The tops of the combustion chambers are supported by girders, four for each chamber. Each girder is composed of two plates 2 feet 6 11/16 inches long, $7\frac{3}{4}$ inches deep and $\frac{3}{4}$ inch thick. Each girder has three stay-bolts $1\frac{1}{2}$ inches in diameter, equally spaced in the direction of its length. The girders are in no way stayed to the shell of the boiler.

The tubes are all seamless, cold-drawn steel, 3 inches outside diameter, 7 feet $4\frac{1}{8}$ inches long. In each boiler there are 324 plain tubes, No. 8 B. W. G., and 180 stay tubes, No. 6 B. W. G. The tubes are spaced $4\frac{1}{4}$ inches horizontally and 4 inches vertically.

In the steam space of the boilers there are fourteen through stay rods, each $2\frac{1}{2}$ inches in diameter, besides four diagonal stays $1\frac{7}{8}$ inches diameter on each head. The through stays are prevented from vibrating by means of slings from the shell in the middle of the boiler. The portion of the heads between the tube nests is stiffened by two 5 by 4 by $\frac{3}{4}$-inch angle-bars riveted back to back. The lower part of the heads around the furnace ends is braced by six through stays $2\frac{1}{4}$ inches in diameter.

There is a 12 by 16-inch manhole in the shell of the boiler, giving access to the steam space, and five 11 by 15-inch manholes in each head in the furnace plate. These manholes are properly re-enforced and strengthened, as shown by the detailed drawings.

Photographs, Figs. 1 and 2, give a good idea of the size of the boilers and the design of the riveted joints; while Fig. 2 shows the method of drilling the furnace ends with a Haesler rotary drill.

The Petticoat Pipe.

The petticoat pipe in some form has for years been a feature of American locomotive practice and is more or less of a necessity in view of the limited dimensions of the smokestack on the modern locomotive. It serves in a great measure the same purpose as the tubes of an injector do in inducing the flow of water. The draft of air passing through the flues is led into the bell mouth of the petticoat pipe by the action of the exhaust, and it is essential that in the event of the petticoat pipe being separate from the smokestack its size at the upper end should be proportionate to the size of the smokestack, and it should be set exactly central with the exhaust nozzle and smokestack. The effect of the petticoat pipe in regulating the draft in the smoke-box is coincident with the deflector sheet, and both are intended to create a uniformity of draft through the flues, so that the heat should be equally distributed over the entire area occupied by the flues.

Exact rules cannot be laid down for the location of the petticoat pipe. The distance from the top of the exhaust pipe to the lower edge of the petticoat pipe is usually made about equal to the diameter of the smokestack. A slight change of the height of the pipe has often a considerable effect on the draft and consequently in the steaming qualities of the engine. The uniform appearance of the flues is the best test of the uniformity of draft. Where the draft is strongest the flues are the cleanest, and if flues are partially choked with soot or ashes it is conclusive proof that the draft has not been sufficiently strong in that locality to keep them clean. Generally speaking, if the petticoat pipe is set too high, the draft will be strongest in the lower flues, and if the pipe is set too low, the upper flues will receive the strongest amount of draft. In view of these facts, very little experimenting should be necessary to obtain the best working height at which the petticoat pipe should be kept.

It need hardly be stated that in the case of badly proportioned or badly set petticoat pipes the effect on the fire is of the most pernicious kind. In cases where the fire is burned rapidly out in some portion of the fire-box, it is safe to assume that the cause of the trouble is in the petticoat pipe, and a slight change of position in the pipe will show some variation in the fire-box. The petticoat pipe has long been in service on American locomotives, but it is only in recent years that it is being slowly applied on some of the European railways. The tendency on American locomotives is to make the petticoat pipe a mere extension of the smokestack projecting towards the center of the smoke-box, and doubtless this method will eventually become standard.—*Railway and Locomotive Engineering.*

A Unique Boiler Plant.

In any plant which includes a sawmill there is unavoidably a lot of refuse wood, sawdust, etc., which cannot very well be used as fuel except in a specially designed furnace. The amount of this refuse is usually large, and therefore a furnace or battery of boilers so arranged as to give good results when fired with this kind of fuel should prove a means of economy. Such a plant has been designed by the Moran Company, of Seattle, Wash., for use in their shipyard. This plant has been in successful operation for some time, and while it has proved economical in that the refuse from the sawmill could be burned, the cost of maintenance of the plant is excessive, owing to the character of the boilers and the deterioration of the material caused by the gases from the refuse.

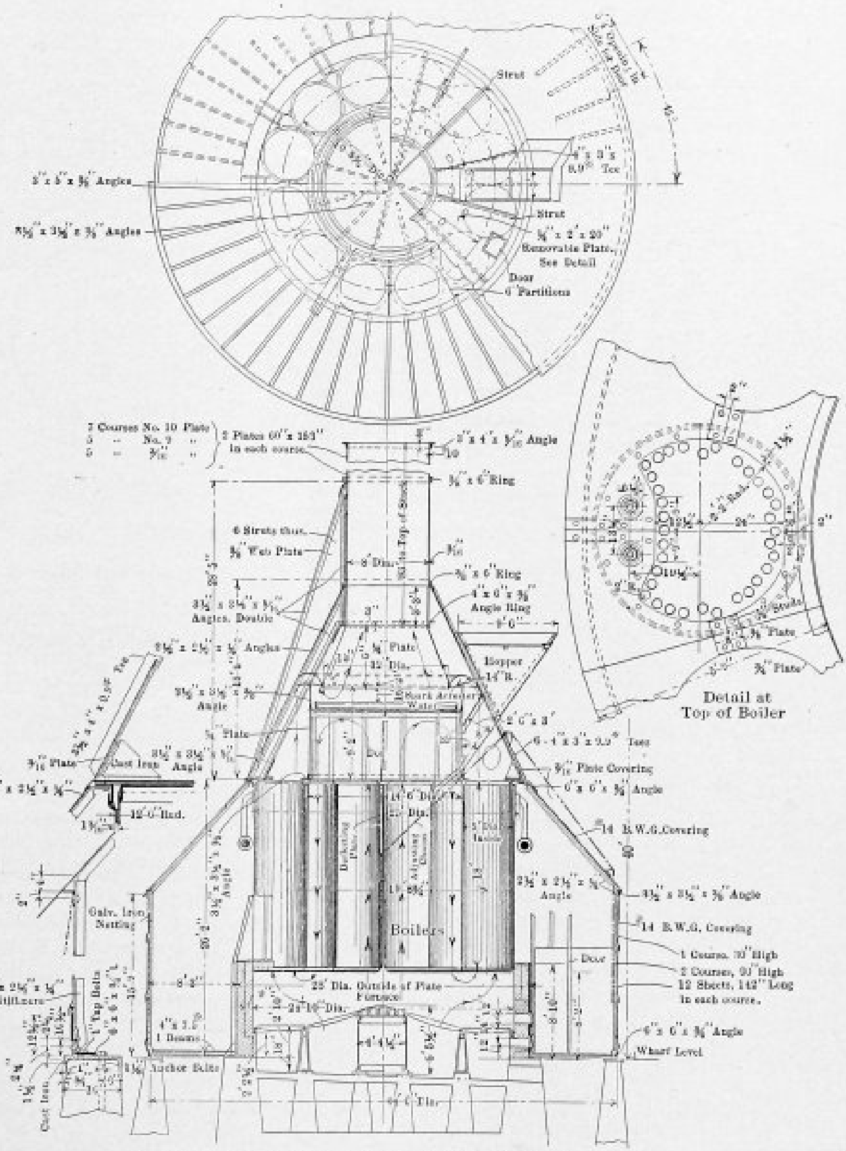
The general arrangement and details of construction of the plant are shown in the drawing. There are twelve vertical cylindrical tubular boilers, each 18 feet long and 5 feet in diameter, arranged in the form of a circle, the diameter of which (through the centers of the boilers) is 19 feet $8\frac{3}{4}$ inches. They are set snugly together and the external sections are heavily coated with magnesia boiler covering. Each boiler is individually supported on the concrete foundation and due allowance has been made for expansion and contraction. There are eighty-seven $2\frac{1}{2}$-inch tubes in each boiler. The average working pressure is 135 pounds per square inch.

Inside the battery is a circular combustion chamber 14 feet 6 inches in diameter and 18 feet high. The top of this chamber is closed by a sheet-iron dome 15 feet in diameter and 6 feet high. Completely covering this dome and flaring to the outer edge of the circular row of boilers is a conical sheet-iron shell 26 feet in diameter at the bottom, 8 feet at the top, and 18 feet 6 inches high. The steel stack, 8 feet in diameter, fits into the top of this conical shell. Underneath the boilers is a circular furnace 24 feet 10 inches in diameter. The grates are supported at the center by a steel pier 4 feet $4\frac{1}{2}$ inches in diameter and 6 feet $5\frac{1}{2}$ inches high. The combination of grates forms a flat cone, with its apex two feet above the base.

The refuse conveyer from the mill dumps the fuel into a sheet-iron hopper situated 40 feet above the floor level. From the hopper the refuse falls into a chute, 2 feet 6 inches by 3 feet, which leads into the circular chamber under the dome. Here the fuel strikes the deflection plates and falls in a fairly even layer on the grates below.

The chamber under the dome, into which the refuse falls, is usually half full of burning fuel and subjected to intense heat, much of which is absorbed by the adjacent boiler shells. After combustion, the hot gases pass up through the tubes in the ordinary manner and come out in the conical chamber surrounding the interior dome; from here they pass through the spark arrester and find their way up the stack. The top of the stack is 140 feet above the floor level, so there is ample natural draft.

A 7-inch header in the form of a ring surrounds the 12 boilers, from each of which is tapped a 4-inch copper pipe leading into the header. Inasmuch as the upper ends of the boilers and a portion of the tubes are subjected to heat from the combustion chamber, the steam delivered into the header is materially superheated, so that the boilers easily attain normal economy. The feed-water connections screw into special cast-iron fittings at the lower ends of the boilers. Each boiler has its individual safety valve, gages, blow-off and other fittings. The ashes drop into a circular pit containing the ash conveyer, which carries them out and deposits them in the



PLAN AND ELEVATION OF THE MORAN REFUSE BOILER PLANT.

bay. The boiler house is of sheet iron, circular. There is a space of 8 feet 3 inches between the boilers and the inside wall of the house.

These boilers are as nearly automatic as can be in a plant of this size. One man on each shift operates the battery easily and efficiently. If repairs are required on any boiler, it is not necessary to shut down the whole battery while the defect is being remedied, but the pipe connections are unfastened and with a nearby derrick the boiler is removed bodily, the hole left in the combustion chamber being temporarily bricked up. This has been accomplished in a single night without causing one hour's operating delay.

Concerning Side Sheets.

A test made some time ago on the Delaware, Lackawanna & Western Railroad to investigate the presence of a film of steam against the fire-box side sheet and referred to during a discussion before the recent convention of the Traveling Engineers' Association, is one of the indications of interest in the ever live subject of improving boiler design.

In preparing for the test referred to, a gage cock was applied to each side water-leg of a high-pressure boiler on a locomotive in freight service. The gage cocks were inserted in the outside sheets and so adjusted as to reach within 1/8 inch and 1/4 inch of the side sheet on each side respectively. The gage cocks were placed 22 inches above the mud-ring and at about the center of the length of the fire-box. Each gage cock was introduced into a washout plug, which was in turn screwed into the outside sheet.

Careful observation of these gage cocks while on the road showed that, upon opening a gage cock through one-quarter of a turn, steam would be discharged while the engine was working with full throttle and the safety valve unseated, while a solid stream of water would be drawn off when the throttle was closed. These observations indicate very clearly that water does not remain in contact with side sheets when an engine is working hard, but rests solidly against the sheets when the throttle is closed. Evidently the intense heat developed by the increased rate of combustion of the fuel on the grate at a time that the engine is working hardest causes an insulating film of steam between the fire-box sheet and the water. After the throttle is closed and when the heat from the fire becomes less intense, it seems that this film of steam disappears and the water is allowed to come in contact with the sheet again.

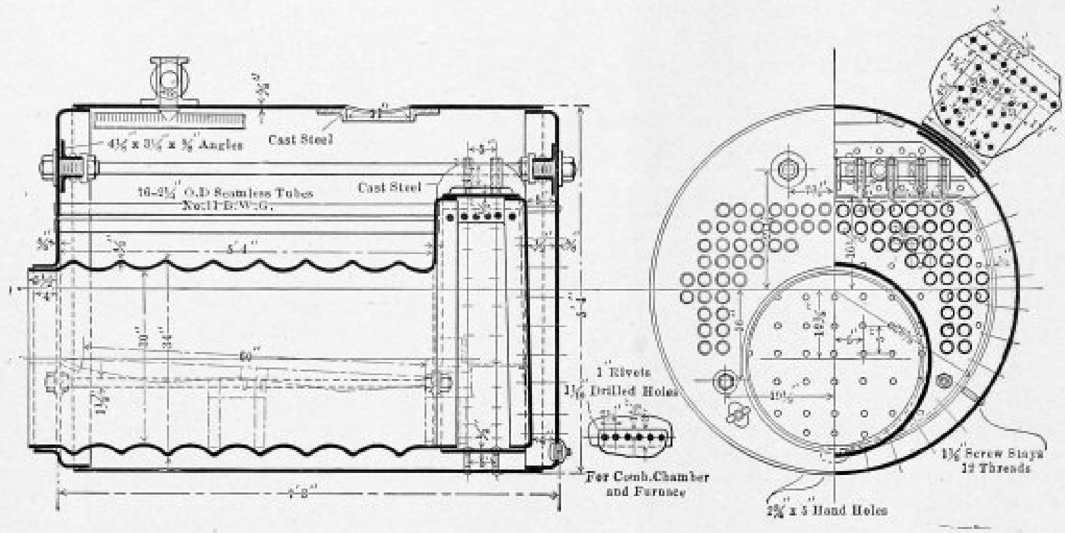
This test corroborates in a measure the results obtained by similar tests made on the A., T. & S. F. Railway and referred to by Mr. George R. Henderson, in his remarks before the convention of the Railway Master Mechanics' Association in 1904, when he said that from experiments made by gage cocks put through the outside sheet so as to extend within different distances of the inside sheet, apparently a film of steam about ¼ to ⅜ inch thick was found against the side sheet.

The presence of a film of steam between the side sheet and the water is injurious to the metal, as it causes the sheet to crack and to bulge between stay-bolts as well as to leak at stay-bolts. By displacing the water immediately adjacent to the sheet, the metal is allowed to reach a temperature higher than that of the surrounding water, when the rate of combustion is highest and the heat from the fire is most intense. When this film is dissipated the water comes in contact with the overheated sheet, reduces the sheet to the temperature of the water and causes sudden contraction in the metal. Continued repetition of this process naturally causes the sheet to deteriorate materially.

That these cracks which develop in side sheets have their origin in expansion and sudden contraction, due to the metal being subjected to an intense heat and then suddenly cooled, seems to be evidenced by the fact that sheets begin to crack on the water side.

It is believed that the presence of a film of steam against the fire-box side sheet of a locomotive boiler cannot be eliminated entirely, even though the depth of the volume of water surrounding the sheet should be increased beyond practical limits. The ill effects of this insulating film of steam are aggravated by poor circulation and by bad water, which has a tendency to foam and prime. Alleviation, then, may be looked for with good water and with good circulation.

In the last few years much attention has been directed toward improving circulation by widening the mud-ring, and by so designing that the water-leg is wider at the top than at the bottom, as well as by increasing the width of bridge between boiler tubes. It would be instructive to learn to what extent longer lives of fire-box sheets have been obtained by improvement in design of boilers to provide for better circulation. Systems of treating boiler feed-water and systems of washing locomotive boilers with hot water have produced very beneficial results, and with the advantage of such improved conditions, it would be interesting to know to what extent the railways at large have profited by the investigations and reports of the master mechanics' committee on improvement in boiler design.—*Railway Master Mechanic.*



LONGITUDINAL AND TRANSVERSE SECTIONS OF AUXILIARY BOILER.

An Auxiliary Boiler.

On the revenue cutter No. 15, now under construction by the Pusey & Jones Company, Wilmington, Del., is to be fitted an auxiliary boiler, as illustrated. The steam and water drum will have a diameter of 42 inches.

This boiler, of the horizontal return fire-tube type, designed for 200 pounds steam pressure, will be 5 feet 4 inches in outside diameter and 7 feet 3 inches long. It will have one corrugated suspension furnace ½ inch thick, 30 inches inside diameter and 5 feet 10 inches long. There will be seventy-six steel tubes, No. 11 B. W. G., 2¼ inches outside diameter and 5 feet 4 inches long. The grate surface will be 12.5 square feet, heating surface 296 square feet, calorimeter area 1.75 square feet. The ratio of heating to grate surface will be 23.7, and of grate to calorimeter area 7.1 to 1.

The uptake and funnel will be of sufficient size to give at all points a clear area equal to at least one-seventh the grate area. The uptake will be of three thicknesses of steel plate with double spacing of 2 inches. The funnel, which will measure 48 feet in height above the base line, will consist of inner and outer casings 5 inches apart. The inner casing will be made of No. 7 U. S. S. G. plates in the lower half and No. 9 in the upper. The outer casing will be of No. 12 plates.—*Marine Engineering.*

According to statistics given by the *Iron Age* the production of structural shapes in the United States in 1906 reached a total of 2,118,772 gross tons. This is a marked advance over the output of 1905, which was 1,660,519 tons. This gain, which amounts to 27.5 percent, was greater than the gain in any other line of finished material, the increase of all forms of rolled products being about 16 percent. For 1994 the total production of structural steel was 949,146 tons; for 1903, 1,095,813, and for 1902 and 1901, 1,300,326 and 1,013,150 tons, respectively. The average for the four years, 1901 through 1904, is therefore 1,089,609 tons, or about one-half the total production for 1906.

Layout of an Up-take.

BY HENRY MELLON.

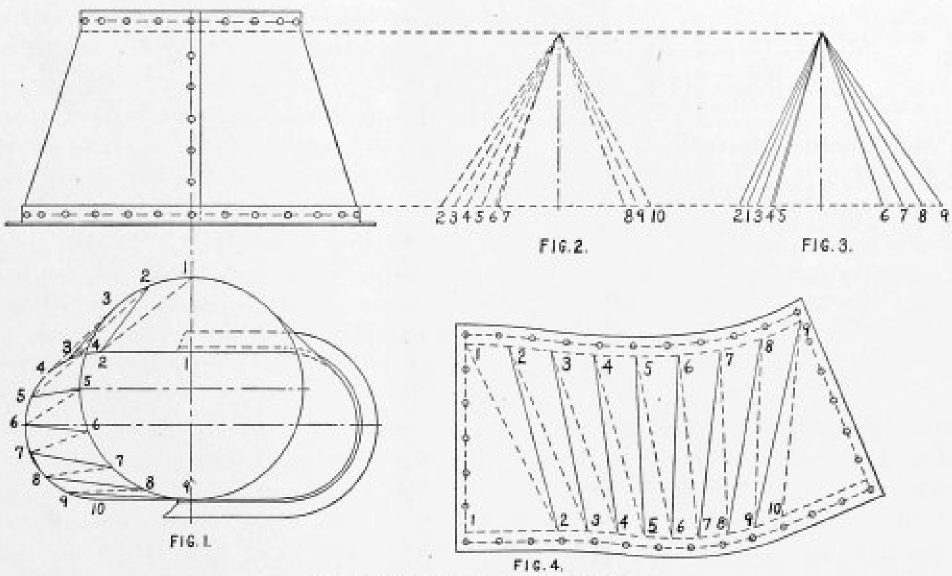
Two views of the up-take are shown in Fig. 1. The upper view is a side elevation and the lower view a plan, one-half of which is divided into triangles for the purpose of laying out the pattern. Instead of laying out the pattern at once, according to the lines through the rivet holes, lay it out to the flange lines where the sheet is bent to fit the angle-iron at the bottom and where it is flanged to fit the vertical stack at the top. After the pattern has been drawn to these lines the required amount can be added for the flanges and laps.

It will be seen from the plan, Fig. 1, that the up-take has an oblong base, while the top is of circular section, to fit an ordinary round stack. Also it should be noted that the centers of the top and bottom of the up-take do not coincide. This frequently happens in cases where some obstacle prevents erecting the stack directly over the center of the oblong base.

As the surface of the up-take forms an irregular tapering article it must be laid out by triangulation; that is, the surface must be divided into a number of triangles, the length of whose sides can be easily found, so that the triangles may be laid out flat in the pattern. To locate the triangles divide the semi-circle which represents one-half of the upper base into any number of equal parts. In this case it has been divided into eight equal parts, numbered as shown, from 1 to 9, inclusive. Also divide the semi-circle 2-6-10, which forms the curved part of the lower base of the up-take, into the same number of equal parts, numbering the points of division in a similar manner. Now connect the points which have the same numbers in both the upper and lower bases by solid lines, as lines 2-2, 3-3, 4-4, 5-5, etc., also draw the dotted lines 1-2, 2-3, 3-4, 4-5, 5-6, etc.

The lines just drawn divide the surface of the up-take into triangles, but the length of the lines shown in the plan is not the true length of the lines as they must be laid out in the pattern, since whatever is shown in the plan is simply a plan view, and represents the true size only when the line lies entirely in a horizontal plane. Since the two bases are parallel, and each line is drawn from one base to the other, the true length of all the lines can be found by drawing right-angle triangles, the height of which is equal to the distance between the flange lines in the upper and lower bases of the up-take, the other side being equal to the length of the line, as shown in the plan view. These triangles have been drawn in Figs. 2 and 3, the dotted lines and solid lines having been separated in order to avoid confusion. All lines in Figs. 2 and 3 are numbered to correspond with the lines in the plan, Fig. 1, so that the true length of each line shown in Fig. 1 can readily be obtained from either Fig. 2 or Fig. 3 when required.

We are now ready to lay out the pattern for the up-take, or rather the half pattern, since the up-take will be made in two sheets, which are of exactly the same dimensions. First draw the line 1-1, Fig. 4, and with 1 as a center and the trams set to the distance 1-2, the half length of the straight portion of the oblong base, Fig. 1, draw an arc through the point 2. From the other end of the line with 1 as a center, with the trams set to the length of the dotted line 2, Fig. 2, draw an arc intersecting the one previously drawn locating the point 2. Also with a pair of dividers, set to a length equal to the length of one of the equal spaces in the large semi-circle, Fig. 1, lay off the space 1-2 in the upper edge of the pattern, Fig. 4. Then with 2 in the lower edge as a center and with the trams set to the length of the solid line 2, as measured from Fig. 3, draw an arc intersecting the arc previously drawn through the point 2, locating the point 2 in the upper edge of the pattern. Proceed in a similar manner to locate the points 3, 4, 5, 6, 7, 8, 9 and 10, then add on the flat portion of the pattern which forms the front of the up-take. Lay off the required space at both top and bottom for the flange, and beyond this the necessary amount for the lap all around the plate. Space in the rivet holes at the required pitch and the pattern is completed.



DETAILS OF LAYOUT FOR AN UP-TAKE.

Marine Boiler Plate Tested by the Government.

During the year ending June 30, 1907, 5,824 marine boiler plates were tested in the mills by assistant inspectors of the United States Steamboat Inspection Service. Of this number 4,751 were accepted and 1,073 rejected. The following reasons are given why the rejected plates failed to pass inspection: Six were spoiled at the shears after inspection, 30 were lost in the shipping house, 419 failed to show the required tensile strength, 47 were deficient in elongation, 11 were laminated, 61 were light gage and 80 heavy gage, 101 failed to show the required contraction of area, 150 were rejected on account of bad surface and 168 because they failed to come up to the requirements of the bending tests.

The Boiler Maker

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The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Riveting vs. Welding.

Riveted joints have always been an expensive and troublesome part of a boiler to construct. An ideal boiler shell would be one in which there were no seams, so that the entire shell would be one homogeneous piece of metal, all parts of which were equally strong. A riveted joint must always be weaker than the solid plate, unless the plate at the joint is up-set so that its thickness is greater than the thickness of the rest of the shell, an operation which for practical reasons is impossible. The best-designed riveted joints rarely have more than 90 percent of the strength of the plate which they join, while the ordinary double riveted lap and butt joints have a very much less efficiency, ranging from 65 to 85 percent. Furthermore, it takes skilled labor and expensive machinery to lay out the seams and punch or drill the rivet holes and drive the rivets, and, even with the best work, there is apt to be trouble in making the joints steam tight, for the rivets must be thoroughly up-set in the holes and the edges of the seams carefully calked.

It has been estimated in the case of a 72-inch by 18-foot horizontal tubular boiler built to withstand a pressure of 125 pounds per square inch that the total cost of labor and material used in the boiler would be about $561, of which $448, or 80 percent, is the cost of material, and $113, or 20 percent, is the cost of labor. Of this amount, the cost of labor on the riveted joints alone—that is, of laying out the rivet holes, punching, riveting, etc.—is about $21, or 19 percent of the cost of labor, and 3.7 percent of the total cost of the boiler. The additional material; that is, butt straps or laps and rivets, costs about $21, or 5 percent of the cost of material and 3.8 percent of the total cost of the boiler. Therefore, the cost of the riveted joints alone is about 8 percent of the total cost of the boiler. This is assuming that the longitudinal joint is a double riveted butt joint and that the holes are punched and all rivets driven on the bull machine. If a stronger joint were used, or if the holes were drilled or the rivets driven by hand, the cost of the riveted joints would be increased.

The only possible substitute for riveting seems to be some form of welding in which the metal itself is structurally united in such a manner that the finished product forms one homogeneous piece of uniform quality and properties throughout. Furthermore, in order for such a system to be of any practical use, the tensile strength of the welded joint must be as great or greater than that of a riveted joint, and the cost of doing the work, including the fixed charges on the apparatus, must not be greater than the cost of riveting, that is, it must be less than 8 or 10 percent of the total cost of the boiler.

The ordinary method of welding by mechanical means, such as hammering, cannot be used in welding boiler shells, both for practical reasons and because the strength of a weld made in this manner is always uncertain. There has recently come into use, however, a system known as autogenous welding, in which the metal itself is raised to a temperature sufficiently high to cause it to be its own joining material; that is, the parts are joined together by the fusion of their own substance without mechanical aid. Such a process requires that only a small area of the metal in the vicinity of the joint be raised to a high temperature, and for thus purpose electricity was first used. While the cost of electricity for this purpose is not excessive, the strength of the joirt is only about 40 or 50 percent of the strength of the metal, so that it is rarely used, except on castings.

The second stage in the development of autogenous welding was the oxyhydrogen blowpipe, and this is now successfully used on light plates. It is claimed that a joint of perhaps 95 percent of the strength of the metal can be made. The temperature (2,000 degrees Fahrenheit) obtainable with this blowpipe is, however, somewhat less than the melting point of mild steel (between 2,700 and 2,800 degrees Fahrenheit), so that for thick plates the heating must be continued for some time, and therefore the consumption of oxygen and hydrogen rapidly increases with the thickness of metal being welded, making the cost of welding thick plates prohibitive.

A still more recent development is the use of the oxyacetylene blowpipe, and this seems to have been fairly successful, since a very high temperature (3,000 degrees Fahrenheit) can be obtained with it, so that even thick plates can be welded rapidly without the use of an excessive amount of fuel. Both oxygen and acetylene can be produced or obtained commercially at a reasonable price, and the apparatus required is not very complicated, the blowpipe itself being a small brass instrument weighing only about 2 pounds, which can be readily handled by an inexperienced workman.

At present, the use of autogenous welding will probably be confined to repair work, for which it seems particularly well adapted on account of its portability. It certainly will not be used for welding the seams of large boilers or pressure tanks until it is absolutely known that a reliable weld can be made which will be at least 85 percent as strong as the metal itself.

Convention Announcements.

Contrary to the usual custom, the annual convention of the American Boiler Manufacturers' Association of the United States and Canada will be held during the summer months. The place of the meeting, this year, is Atlantic City, N. J., and the date July 14, 15 and 16. The headquarters of the association will be at the hotel Marlborough-Blenheim.

The officers of the Boiler Maker Supply Men's Association will meet in Detroit, March 7, to perfect arrangements for the entertainment of the Master Boiler Makers when they come to Detroit for their annual convention on May 26, 27 and 28, 1908.

PERSONAL.

CHARLES E. FRICK, of Boonton, N. J., formerly foreman boiler maker of the New Jersey Boiler Company, has taken the position of general foreman boiler maker at the Philadelphia Iron Works, Philadelphia, Pa.

A. TULLEY has recently been appointed assistant foreman boiler maker of the Erie shops at Meadville, Pa., to fill the vacancy caused by the promotion of Mr. C. E. Lester, who is now general foreman boiler maker of all Erie lines west of Salamanca, N. Y.

J. A. DOARNBERGER, formerly foreman boiler maker with the Norfolk & Western Railway Company, at Roanoke, Va., has been appointed master boiler maker with jurisdiction over all the boiler work of the entire system of the Norfolk & Western Railway. Mr. Doarnberger has always been an active member of the Master Boiler Makers' Association and has contributed much to the discussions carried on at their annual conventions.

ALICK MACFARLAND, formerly of Boston, Mass., has recently gone to Halifax, Nova Scotia, to work as a journeyman boiler maker for the Edward Evans' Steam Boiler Works. Mr. MacFarland was born in Scotland, but has spent the past thirty-five years in Boston. He has also worked as a boiler maker in other parts of the world, having been in South America for seven years. Mr. MacFarland's long connection with the boiler-making industry has given him a thorough knowledge of the business, from laying out to riveting up.

JOHN COOK, of Springfield, Ill., one of the oldest boiler makers now actively engaged in the industry, recently celebrated his seventieth birthday. Mr. Cook has spent nearly fifty-six years of continuous work in a boiler shop, and, furthermore, has three sons and one grandson who are now holding prominent positions in boiler shops in different parts of the country. Mr. Cook's vigor and interest in his trade are evidenced by the numerous contributions and suggestions which appear over his signature in THE BOILER MAKER and other technical papers.

COMMUNICATIONS.

The Opinion of an Old-Time Boiler Maker.

EDITOR THE BOILER MAKER:

On page 50 of the February, 1908, issue of THE BOILER MAKER there is an article embodying the rules prescribed by the Ocean Accident & Guarantee Corporation, Ltd., 350 Broadway, New York, for the operation of steam boilers. In this article it is stated that a leak in a boiler should never be calked or tightened while the boiler is under high pressure. The inspector who laid down that rule cannot be a boiler maker of very wide experience, for it is common practice to calk leaks while a boiler is under pressure, especially when it is being tested under very high pressure, say one and one-half times the ordinary working pressure. I have calked leaks on both large and small fire-tube steam boilers three or four times a week for seven years while the boilers were under 180 and 200 pounds pressure. There were always about four of us hammering on our calking tools for about an hour at each test.

I have also many times hammered up a stay-bolt in a boiler which was under pressure when the holder-on was using a 20-pound sledge and I was using either a 3 or 4-pound hammer. In all such cases the stay-bolt was made tight while the pressure was on the boiler.

The large English boilers described in the same issue of THE BOILER MAKER, or Lancashire boilers as they are called, are a very poor type of boiler, because the amount of heating surface is small. The only available heating surface is that of the two large flues and under half of the shell. If the Englishmen can afford to build boilers with such small heating surface, land and coal and also firemen must be cheap in England.

GOOD-NATURED.

Use and Abuse of Staybolts.

EDITOR THE BOILER MAKER:

The safest and most effective staying for locomotive and marine boilers is a subject of the highest importance. The frequent discussions and conflicting opinions advanced from time to time as to the best methods, etc., are evidence that there is no well settled or uniform plan adopted for this important feature of boiler construction. While it is agreed that metal of high quality and vibratory power is necessary, there seems to be no unity of thought as to the best design of stay-bolt that would come nearest to the qualities of safety, economy and endurance. The strenuous service, the prevailing necessity of rapid heating and cooling of boilers, causing extremes of temperature, the adoption of high pressures and the frequent failures of the constructive parts, often followed by serious results, should attract to the subject our deepest thought and attention.

Stay-bolts have a diversified mission. To the tensile strain, used in sustaining the fire-box sheets in normal position, are added irregular bending forces, due to expansion and contraction. The outer ends of solid stay-bolts are usually at a temperature of less than 300 degrees, while the inner ends are struggling at a temperature of between 700 and 800 degrees F. Torsional strains are also very often in evidence, due to untrue alignment of holes, and thus we obtain from the first day in service, forces bordering on dangerous fatigue of the metal. However, premature or early breakage is often directly due to impure metal or metal not sufficiently cohesive to long endure the frequent reversal of forces. It is quite evident that to obtain reasonable endurance, iron suitable for stay-bolts must receive special attention in manufacture.

The solid stay-bolt, as usually introduced, is far from being safe or satisfactory. Breakages at best are frequent, and unless well covered by regular, capable and experienced inspection, they become a hidden source of danger. We should also remember, that while hammer sounding is somewhat assuring, it sometimes fails to detect bolts actually broken, and the sound test is never certain to discover those partially broken. The latter at times are numerous and form an unsuspected danger. The truth of this will be apparent to anyone making an inspection of the stay-bolts on exploded sheets. It can likewise be seen on fire-box sheets which are removed, because they are crooked or bulged.

Drilling tell-tale holes in the outer ends of solid stay-bolts offers neither safety nor economy. The purpose (self-warners when broken), it is true, is desirable, but they fall short of expectations. The drilling process, when well done, forms a weakness in the stay at a point where much strength and flexibility are required, but when the drill is run off on an angle or not held in line with the center of the bolt, the reduction in strength becomes serious. The tell-tale or blind holes often fill with dirt, which becomes packed in so hard that the self-warning feature becomes nil. Some object to drilling tell-tale holes because of the inconvenience of doing the work, and the time, labor and expense involved. The writer's experience is to the effect that while the expense is important, it is as nothing compared to the resultant weakness, due to drilling followed by breakage, delays to equipment and expense of replacements.

Considerable thought and attention are now given to flexible stay-bolts. The principle at first sight strikes one as having considerable merit, but on deeper thought, the flexible action, under service conditions, will be found not only impossible, but also to involve some serious objections. The inside end of the "Flexible" is attached to the fire sheet in the usual way, the outer end of the bolt with round head resting in a prepared sleeve of corresponding lines, the whole covered by a screwed-in cap. The idea is that the apparent loose attachment of the head to the outer sheet would respond freely to expansion and contraction movement of the inner ends without causing any vibratory strains on the body of the bolt. This, however, is an appeal to theory and does not in practice bear out expectations.

The failure of the flexible action of the head and the consequent breakages just under the head, are due principally to the immense friction between it and the sleeve, brought about by the constant strain of the stay in supporting the sheets. In other words, if the bolt is to be of any use as a stay between sheets, its grip at the ends deprives it of any flexibility other than that obtained by the vibratory action on the body of the bolt. Under the conditions it is as rigid and liable to break as the ordinary solid stay-bolts, and if the "Flexible" develops any marked endurance as compared with the solid, it is due to a superior quality of metal, nothing else.

It is plainly as necessary to cover the "Flexible" stay-bolt by regulation inspection as with the solid type, and as a matter of safety it should be done. From the style of attachment to the outer sheet, it seems impossible to detect the broken bolts by hammer sounds on the inner ends. This leads to the necessity of removing the caps on the outer sheets in order to discover those actually broken. This means considerable time and expense, and not infrequently delays power.

A most undesirable practice in connection with the introduction of the "Flexible" stay-bolts is the necessity of cutting large holes in the outer sheets of the fire-box for the purpose of fitting the sleeves and caps. The holes are of such size for a 1-inch stay, that for a sheet bearing stay-bolts 4 inches apart, it reduces the stock between the edges of holes to 2¼ inches. This is an act of mutilation of the outer sheets that seems hard to justify.

The attention of the writer was called to the use of hollow stay-bolts. The bars from which these bolts are made have a central hole formed by being rolled in the center. This practice assures solidity, increases tensile strength and high elasticity of the metal and prevents any possible defective welds, all being qualities necessary to endurance in stay-bolt service. Having had some prior experience with hollow bars made in this manner, and being troubled with broken stay-bolts on several mountain engines, due to variation of pressure followed by extremes of temperature several times a day, the undersigned had some hollow stay-bolts placed on surfaces giving the most trouble from broken bolts. As the solid bolts and those having drilled tell-tales were removed, they were replaced by hollow bolts. After about a year of this practice, it was noticed that the stay-bolt work at the short-run terminals was very materially reduced. Prior to this, the life of the solid stay with tell-tale drilling was between five and nine months, depending on location of the stay, while after this time, a little over a year, no record was found of a single hollow bolt having been broken, although most of them were located in what was considered the breaking zone. Longer periods of experience with the hollow bolt developed equally good results, the endurance of the hollow bolt being remarkable under the severe conditions existing.

The great endurance shown by the hollow stay-bolts is attributed to several causes. The method of rolling, both at the center and outside of the bars, creates a substantial unity of the metal, assures freedom from improper welds, the pure and high quality of the metal, forming the base from which the bars are rolled, tends to both strength and elasticity, the very qualities required to endure continued reversal of strains longer than iron manufactured under ordinary methods.

The self-warning principle of the hollow stay-bolt is highly appreciated by those directly in touch with power. Eliminating the hammer tests, together with the feeling that no dangerous number can be broken without compelling attention, is regarded as a very satisfactory condition, as it is a positive assurance against boiler explosions or other troubles due to broken stay-bolts.

It is well known that the strength of wrought iron decreases after reaching 350 degrees F. Moderately high fire-box temperatures cause solid stay-bolts to reach the depreciative heat, this being one of the causes which shorten their life. With the hollow stay-bolts in service, a streamlet of cool air passes through each bolt to the furnace, thus holding the metal at a lower temperature, rendering both strength and endurance that cannot be obtained with the use of the highest possible grade of iron in the solid stay-bolt. The greater endurance of the inner ends of the hollow bolts as compared to the solid is very noticeable. This is due to the in-rushing oxygen through the hole, cooling the ends of the bolts and reducing the waste of the iron, due to the high heat of the fire.

On engines whose fire-boxes were fully equipped with hollow stays some fault was found because it was thought too much cool air was entering the furnace. While there was some doubt of this by those who had watched the matter closely, yet it was thought best to reduce the center holes from 3/16 to ⅛ inch, which was done. The amount of oxygen supplied through the ⅛-inch openings seemed to be sufficient to consume the gases and the assistance to combustion was quite apparent.

It is said that a few have closed the center holes at the inner ends of the hollow stays with a couple of blows of the hammer, claiming the entrance of too much cold air. This practice, I am certain, should be discouraged. In order to obtain full benefits from the hollow bolt, the air should be permitted to pass through a ⅛-inch hole to the fire. This will hold the stay-bolt to lower temperature, add to its strength and flexibility, cause greater endurance to the inner ends, and while aiding combustion will add noticeably to the efficiency of the furnace and afford a double advantage for the detection of breakages, should any occur, as the annular hole passes entirely through the bolt, and failure at any point will immediately make itself known.

Hollow stays, with both ends open, will never stop up, as the current of air passing through them always keeps the holes free from sediment. Furthermore, the hollow bolt saves material and time in application and renewals, and also prevents injury to sheets in making renewals, as the operator has a central hole for his drill to follow.

We seem slow to realize, but it is no less a fact, that almost daily in some part of the country broken stay-bolts are responsible for waste of property, for injury to persons, and for destruction to life.

JOHN HICKEY.

TECHNICAL PUBLICATIONS.

Steam and Entropy Tables. By Cecil H. Peabody, professor of naval architecture and marine engineering, Massachusetts Institute of Technology. Size, 5¾ by 9 inches. Pages, 131 + XXIV. New York, 1907: John Wiley & Sons. Price, $1.00. London: Chapman & Hall, Ltd. Price 4/6 net.

This is the seventh edition of tables calculated twenty years ago to accompany the author's "Thermodynamics of the Steam Engine." Since that date important experimental investigations have been made, and this information has been used in recomputing the tables and in making certain changes facilitating their use. All the tables for saturated steam have columns of entropy, due to vaporization, and the table in metric units has been made into a conversion table, by aid of which properties can be found in either metric or English units, or a combination of the two may be used.

The introduction deals at some length with the properties of steam and other vapors, going into the subject from the theoretical standpoint and making use of the calculus. The first table covers saturated steam on the basis of temperature in degrees Fahrenheit. The second table covers saturated steam on the basis of pressure absolute in pounds per square inch. The third table covers saturated steam in metric and English units, based on temperatures. The next eight tables cover properties of saturated vapor of ether, alcohol, chloroform, carbon-disulphide, carbon-tetrachloride and aceton in metric units, and of ammonia and sulphur-dioxide in English units. The remaining tables include one showing the specific gravity and specific volume of liquids, one showing the volume of water at different temperatures based on its volume at 4 degrees C., conversion tables between inches of mercury and pounds per square inch, and a table of corrective factors for superheated steam.

The Temperature-Entropy table occupies fifty-two pages of the book, and is followed by tables of Naperian and common logarithms.

Simple Problems in Marine Engineering Design (Including Turbines). By J. W. & R. M. Sothern. Size, 4¾ by 7¼ inches. Pages, 199 + XI. Glasgow, 1908: James Munro & Company. Price, 2/6 net.

This is the second edition of the work, which is divided into six sections: Simple Engineering Mathematics; General Problems; Engine Design; Boiler Design; Marine Turbine Design; Speed, Consumption and Horsepower Problems. The work is replete with rules and examples, and is intended to be used in connection with a theoretical work covering much the same subjects. With a good knowledge of the general features of the problems, however, the work is entire in itself, and would serve simply as a guide in the working out of the various features of marine engines, turbines and boilers. In each case the answer to every problem is given as a check to the work, and the total number of problems is sufficiently great to give a considerable scope in character. In many cases the problems are made more than usually specific by reference to the name of the ship under consideration.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Can you furnish me with a sketch showing the method of laying out the bottom of a hemispherical tank? I have gotten several rules out of a book, but have not as yet been able to get them to come out very satisfactorily. I should be glad to have some of your contributors furnish this sketch for me. TANK.

A.—See page 74.

Q.—How do you find the working pressure of a boiler? J. L. A.

A.—If the diameter of the shell, the thickness of the shell, and the character of riveting are known, we can figure the working pressure according to the formula:

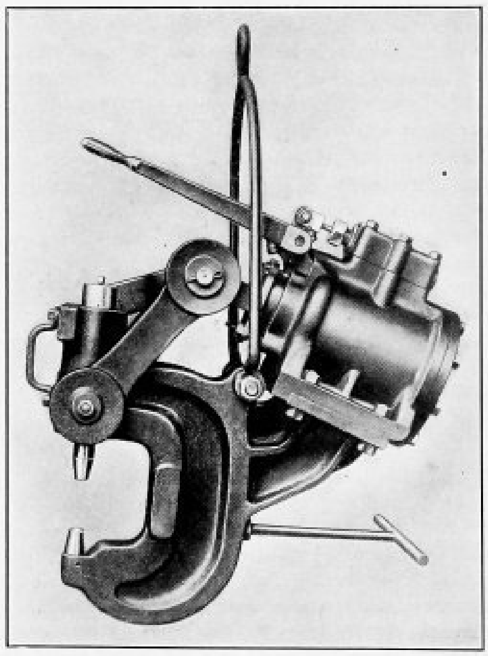
$$P = \frac{T \times t}{\frac{1}{2} D \times f},$$

where T is the tensile strength of the steel of which the shell is made; t is the thickness of the boiler shell in inches; D is the diameter of the boiler in inches; and f is the factor of safety. Suppose we assume that we have material with a tensile strength of 60,000 pounds per square inch, and that the shell has a thickness of ¾ inch and a diameter of 150 inches. If we take a factor of safety of 6, we find that the allowable boiler pressure would be: $P = \frac{60{,}000 \times \frac{3}{4}}{75 \times 6} = 100$ pounds per square inch. This assumes that the longitudinal seam is single riveted. If it is double riveted, we can add 20 percent to the above figure, thus giving a boiler pressure of 120 pounds per square inch.

ENGINEERING SPECIALTIES.

A New Albree Portable Riveter.

Where the work is heavier than the tool it is much more convenient and economical, if not absolutely necessary, to keep the work in a stationary position and use a portable tool. This practice is particularly desirable in riveting heavy and unwieldy structural and boiler work. The hydraulic riveter is not



practical for this service, on account of the difficulty of providing high-pressure water lines and carrying away the exhaust water. An air-driven machine, however, similar to the one shown in the illustration, which is manufactured by the Chester B. Albree Iron Works Company, Allegheny, Pa., is admirably adapted for this work, as the air is conveyed to it by a rubber hose, and the exhaust takes place directly into the atmosphere.

The riveter illustrated has a 6-inch reach, will drive a ⅞-inch rivet, and weighs 850 pounds. When desired this machine may be equipped with the maker's universal bail, which will hold it suspended in any position. It will be noted that only a comparatively small cylinder is used, the necessary pressure being obtained by the toggle leverage shown, and as the rivet is driven by one squeeze the number of rivets the machine can drive is practically unlimited. Therefore, the amount of riveting that can be done is merely a question of getting the machine from one rivet to the next; in other words, the cost of riveting is almost entirely the cost of moving the machine.

To show what has been done with such a machine, under favorable circumstances, the astonishing record of 12,000 rivets driven in ten hours' time is claimed. The work was a long plate girder, and the machine was suspended from a trolley on an overhead runway. The operator, with practice, had become very expert in moving the machine from one rivet to the next, the spacing being equal, and several heater boys keeping the holes ahead of the machine full of hot rivets. The rivets were ¾ inch diameter and driven hot, and the dies were replaced by cool ones at given intervals.

The next best record known is 10,000 rivets in ten hours' time, under very similar conditions. These figures, of course, are merely of interest to show what has actually been done. The type of work, of course, is all-important. On boiler work, where the rivet must be steam-tight and well driven, no such record could possibly be made.

Portable riveters have a wide range in practice and seem to be coming more and more into favor.

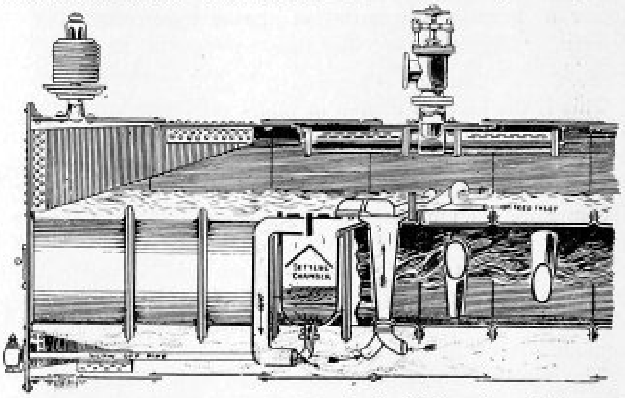
A Display Stand for Wrenches.

A convenient and useful display stand for wrenches has recently been placed on the market by the Frank Mossberg Company, Attleboro, Mass. This company manufactures thirty-

two different sizes and types of wrenches ranging from 5 to 10 inches. Different wrenches are designed to meet all conditions and requirements of a machinist or boiler maker. In order to display these wrenches to the best advantage the stand shown in the illustration has been designed. Its usefulness is at once apparent.

A Boiler-Water Circulator.

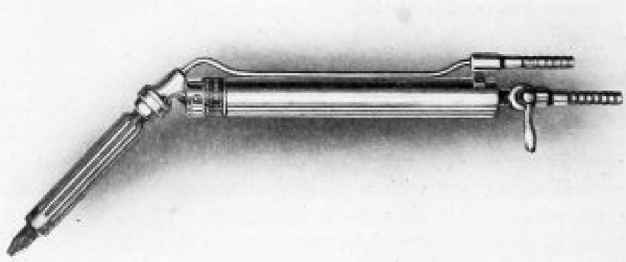
This device has been placed upon the market by the British Boiler Water Circulator Syndicate, of Nottingham. It is claimed not to require any structural alterations whatever to the boiler, and that it can be removed, inspected and replaced by an ordinary workman in about two hours. The object of the appliance is to increase the water circulation and facilitate steam generation by giving greater freedom to the gas-containing globules formed on the heating surfaces. It is entirely automatic in action. The feed water sent into the boiler must first pass through the apparatus illustrated, where it is not only heated, but is also cleansed and softened, while, further, the



grease is extracted. The feed inlet is indicated, and the settling chamber for impurities is also shown. The sediment, etc., can be ejected by means of a blow-off cock and pipe, and in fact the only attention necessary is that wanted for occasionally blowing out the impurities which are trapped. The construction is perfectly simple, and there are no delicate parts. The usefulness of moving water rapidly over the heated surfaces of boilers is now being recognized, and in increased steaming capacity and in the use of impure or dirty water this appliance should show advantages.

An Oxy-Acetylene Welding Apparatus.

The development in all directions which has taken place during the past year in the introduction of modern methods into boiler-shop practice has been very marked, but probably the most radical change of all is in the application of the oxy-acetylene blowpipe. This is now being employed as a substitute for riveting and brazing, and its use is giving rise to new methods of manufacture, which affect, not only the design of the boiler itself, but also make a material modification in the

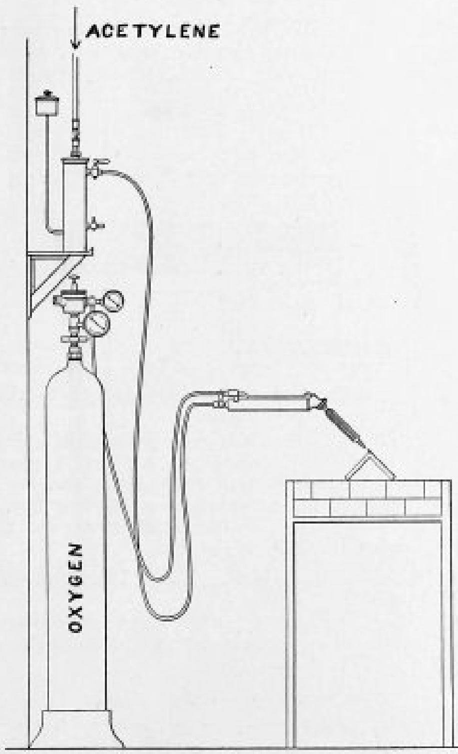


construction of many of the ordinary mountings and steam fittings used.

The process of welding by means of the oxy-acetylene blowpipe is comparatively new to this country, though in Europe it has been developed on an exceedingly large scale. The cause of this is no doubt to be traced to the fact that until within a very few months it has been impossible to obtain oxygen in a suitable form in sufficiently large quantities at such a price as would warrant its application in this manner. Now, however, that the direct production of oxygen from the atmosphere by means of Dr. Carl von Linde's system of fractionation is being actively carried out on a commercial scale, an extensive plant for this purpose having recently been equipped at Buffalo, N. Y., by the Linde Air Products Company, 155 Chandler Street, it is reasonable to suppose that this method of welding will be largely used in the boiler shops and shipyards of this country also.

It must be recognized that, from the very nature of the process, a seam welded in this way does not possess quite the same tensile strength as the original material. The reason of this is obviously due to the fact that iron and steel plates owe some appreciable percentage of their strength to the mechanical process to which they have been subjected in the mills. It is, however, claimed that, on the average, the tensile strength of such a welded seam is only about 15 percent less than that of the original material. With thin sheets the falling off is less marked and an ultimate strength of over 30 tons per square inch at the joint has actually been recorded.

With this, as indeed with any other process, the results obtained are largely dependent on the personal equation of the operator, both in regard to the quality of the work turned out and the speed at which such welding can be done. It may,



however, be stated that the method presents no particular difficulties, and any ordinary workman of average intelligence very quickly becomes proficient in its application. A general idea of the speed at which work of this nature can be done may be gathered from the following table, in which the approximate foot-run welded per hour is given for various thicknesses of plates:

Thickness of Plates, Inches.	Approximate Foot-Run Per Hour.
5/64	35
1/8	20
3/8	10
1/2	6

These figures are average results, obtained by working on cold plates. By previously heating the parts to be welded, in the neighborhood of the seam, the time and cost of making the weld may be reduced from 30 to 50 percent in the case of plates 1/4 inch in thickness and upwards.

It is not claimed that the use of the oxy-acetylene blowpipe will entirely supersede ordinary forge welding, but it is such a clean, convenient and portable tool that it enables a large variety of different and complicated welding to be carried out *in situ* where riveting would otherwise be necessary. Since the cost of the process compares very favorably with that of riveting, it therefore greatly extends the scope of welding. It is impossible to enumerate in detail all the work which may be rapidly and economically executed by this blowpipe, but among many other applications may be mentioned, in particular, its use in welding flanges on pipes, and in the construction of superheaters. Probably one of the widest fields for the adoption of the process is in keeping down the "heap." There are very many instances, particularly in pressed steel work, where, owing to the development of a small split or the opening of a seam, a large and valuable piece of work has to be scrapped. A few minutes' application of the blowpipe will, at an almost insignificant cost, in most cases enable such a flaw to be repaired and the piece put into use.

A still more interesting application of a modified form of the welding blowpipe is a "cutting" blowpipe. It is a matter of minutes only, by means of this tool, to cut out sections of plates up to over an inch in thickness, with such extreme precision that practically no hand work is subsequently required. This system is a great advance on the present costly and laborious method now generally employed, and it is applicable, not only to the formation of manhole and other openings in boiler and tank work generally, but also in marine construction in forming openings in decks and bulkheads.

The actual outlay involved in installing such a welding installation is comparatively trifling, even including the acetylene generator, which, for ordinary shop work, is indispensable. For outside work, and for use in emergency, a small cylinder of dissolved acetylene may be used.

One of the illustrations represents diagrammatically a complete oxy-acetylene blowpipe installation, with the exception of the acetylene generator, which may be placed in any suitable position at any convenient distance from the blowpipe apparatus. The plant consists of the blowpipe, the hydraulic back-pressure release valve and a cylinder of oxygen fitted with an automatic pressure regulator.

The oxy-acetylene blowpipe (Fouché patent) is also illustrated. It is a low-pressure blowpipe, constructed on the well-known injector principle, and is very carefully designed and proportioned to meet all the special conditions with which an oxy-acetylene blowpipe must comply. It is perfectly safe for use, being so constructed that the flame cannot strike back. The gases are well mixed in the injector chamber before they issue from the nozzle of the blowpipe, and it is claimed that the nozzle itself is so designed that the possibility of carbonaceous deposit in the orifice is practically obviated.

SELECTED BOILER PATENTS.

Compiled by
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LOAN AND TRUST BUILDING,
Washington, D. C.

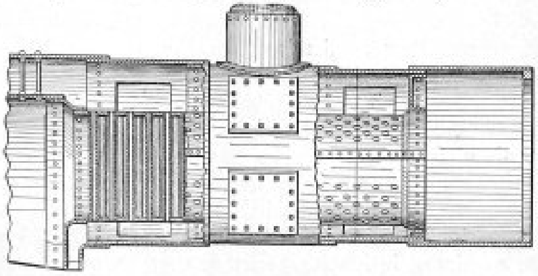
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

875,020. AUTOMATIC STOKER. Henry E. Wallis, of Terre Haute, Ind., assignor to Wallis Stoker & Manufacturing Company, of Terre Haute.

Claim.—In a stoker of the chain grate type, the combination; with a suitable supporting frame, a pair of chain-supporting shafts journaled one at each end of said frame, an endless chain grate carried by said shafts, a substantially horizontal support for said chain grate between said shafts, of means for driving the shaft at the inner end of the structure whereby the tight side of the belt will be the live side, a coking plate arranged above the chain grate, a pivoted tail-plate forming a connection between the inner end of said coking plate and the chain grate, and means for successively delivering small quantities of fuel to the coking plate. Five claims.

874,423. BOILER. William J. Ogan, of Dayton, Ohio, assignor to Ogan Mechanical Appliance Company, of Dayton.

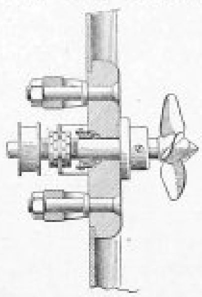
Claim.—In a boiler, a shell, a fire tube formed of upper and lower curved plates within said shell, one end of said fire tube terminating in a bell shape, means for supporting said bell end



within the shell, a fire-box to which the other end of the fire tube is connected, and a series of water tubes extending across the fire tube throughout its length. Three claims.

874,470. CIRCULATOR FOR STEAM BOILERS. Edwin J. Wheeler, of Brooklyn, N. Y.

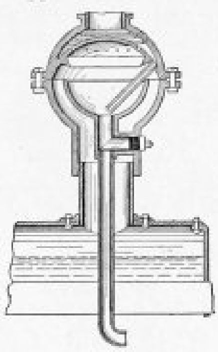
Claim.—The combination of a boiler provided with a manhole having a removable cover, means for securely locking the cover in place, a rotary shaft extending through said man-



hole cover and having a bearing thereon, an agitator mounted upon the inner part of said shaft so as to be maintained within the body of water within the boiler. Three claims.

874,971. WATER ELIMINATOR FOR STEAM BOILERS. James Long, of Minot, N. D.

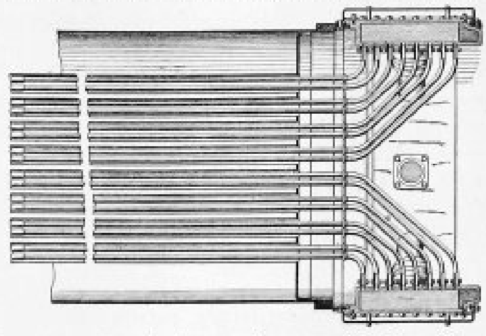
Claim.—The combination with a boiler and a steam conduit leading therefrom of a water eliminator comprising a two-part hollow bulb rigidly secured together, a drip cup in the lower section of said bulb having a drain pipe depending into the boiler, a perforated dome-like partition in the upper section of said bulb, forming a supplemental condensation chamber in the



top of the bulb, a drain tube secured to said perforated dome-like partition at a point outside of said perforations and leading from the lower portion of said supplemental condensation chamber into said drip cup, an annular deflecting rib on the under surface of said dome-like partition, outward of the perforations thereof, and one or more annular deflecting ribs on the upper interior surface of said supplemental condensation chamber. One claim.

875,895. STEAM BOILER SUPERHEATER. Francis J. Cole, of New York, N. Y.

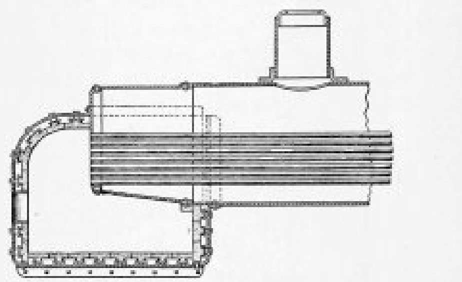
Claim.—In a steam boiler superheater, the combination of a steam header which is divided by transverse partitions into a plurality of communicating steam receiving compartments and a plurality of communicating steam delivery compartments, and is provided with openings or nozzles for the connection of the receiving and delivery compartments to a steam supply pipe and a steam delivery pipe, respectively, a plurality of pairs of superheater pipes having their forward portions bent laterally to communicate with the steam receiving and delivery compartments, respectively, and bolts independently



connecting the pairs of pipes to the steam header. Twenty-two claims.

875,349. STEAM BOILER. Francis J. Hickey, of Sacramento, Cal.

Claim.—In a locomotive type of boiler having internal fire tubes, a furnace inclosing the rear and lower part of the boiler, from which furnace the tubes extend, said furnace being made



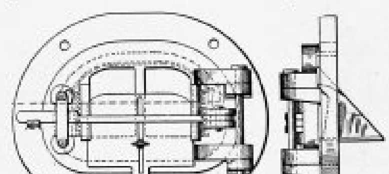
in detachable sections, and removably secured to the boiler above the water-line. Three claims.

876,728. GRATE. James Reagan, Philadelphia, Pa.

Claim.—In a grate, a plurality of choppers, a plurality of lifting fire-bars intermediate said choppers, a rocking bar for said choppers, means for actuating the rocking bar, a connecting bar for said lifting fire-bars, and means for actuating the latter. Sixteen claims.

876,819. FURNACE DOOR. Haze Hamilton Magwire, Montpelier, Idaho.

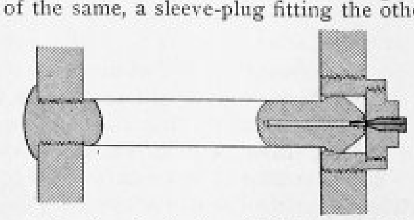
Claim.—A door for furnaces having an opening formed therein and provided on its rear face adjacent to the sides of



said opening with vertical overhanging flanges arranged in downwardly converging relation and a hood embodying straight sides having beaded front edges engaged with said flanges and an inclined rear portion. Four claims.

876,912. FLEXIBLE STAY-BOLT. Harvey A. Pike, New York, N. Y.

Claim.—A stay-bolt structure, comprising a bolt suitably secured to one portion of a boiler shell and having a head at the other end of the same, a sleeve-plug fitting the other shell and



having a seat for the head of said bolt, said bolt being centrally bored, an independent plug fitting said sleeve plug for normally retaining said bolt in place, a tube extending from said independent retaining plug and entering the bore of the bolt, and a centrally bored screw plug for securing the upper end of said tube in said independent plug. Twelve claims.

THE BOILER MAKER

VOL. VIII APRIL, 1908 No. 4

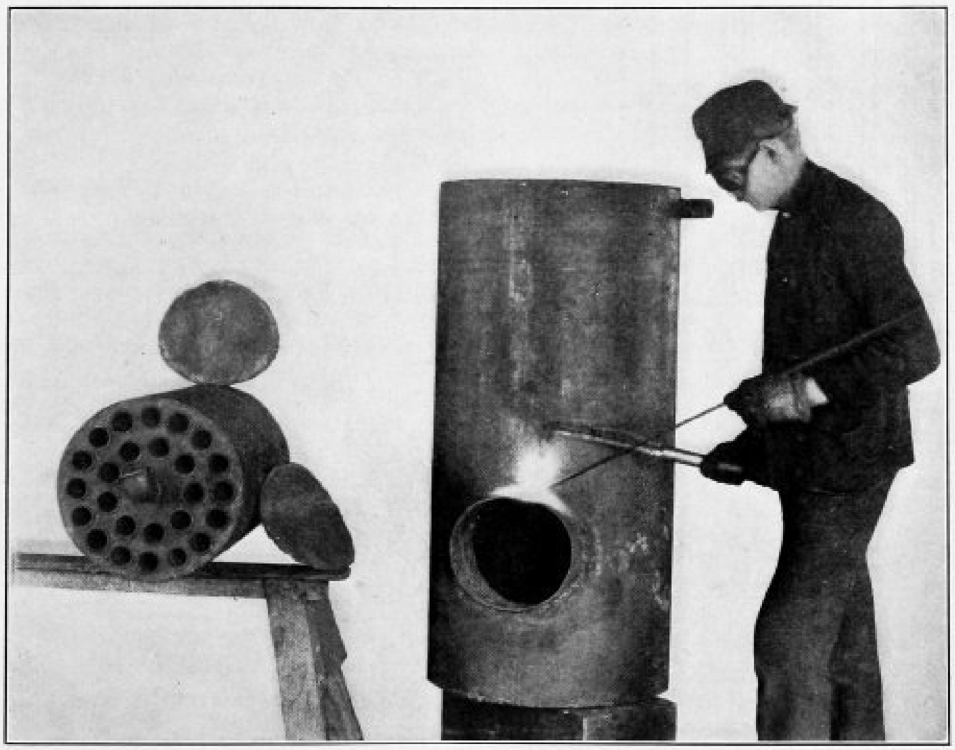
A WELDED BOILER.

BY CHAS. F. BENNETT.

Having been identified with the boiler making industry for some thirty years, the writer noticed in a recent number of THE BOILER MAKER a description of the oxy-acetylene process of welding. This immediately awakened a desire to learn more of its use as applied to the boiler shop. So, with Mr. B. M. Brennan, the owner and manager of the Connecticut Boiler Works, Bridgeport, Conn., he visited a local welding shop to witness a practical demonstration of the art. This demonstration certainly appeared to be cleverly done, but, like the men from Missouri, "we had to be shown."

A design for a boiler was suggested by the writer, and this was approved by Mr. Brennan, who furnished and formed the stock for the sample boiler, which is shown in the photograph and whose dimensions are given in the line drawing. The material used was flange steel of 60,000 pounds tensile strength, furnished by the Glasgow Iron Company, Pottstown, Pa. The shell of the boiler is 4 feet long and 23 inches in diameter; the furnace about 24 inches long and 19 inches in diameter. A tube drum 23 inches long by 15 inches in diameter is fitted in the upper half of the boiler. All shell plates are made of quarter-inch steel. The two flat heads for the drum are 5/16 inch plate and were punched full size for twenty-five 1¾-inch tubes with the burr side out. The boiler, therefore, really consists of a waterleg 2 inches wide the entire length of the boiler, and a tube drum in the upper part of the boiler to secure the greatest possible amount of heating surface.

The plates were rolled and the edges beveled for an inside contact, forming a "V" outside to be filled with steel of the same grade as the plates themselves in the process of welding.



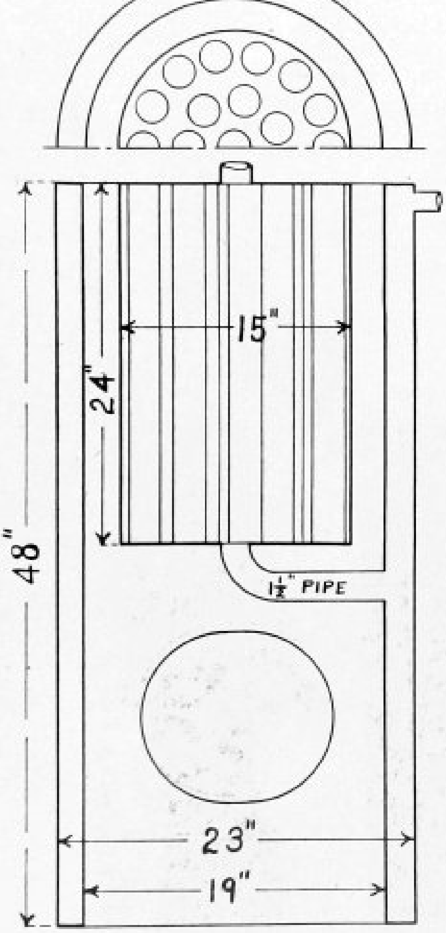
WELDING THE DOOR RING TO THE SHELL WITH AN OXY-ACETYLENE BLOW-PIPE.

After the plates were welded the water space was closed up with flat rings of 5/16 inch stock placed nearly flush at the ends in a manner suitable for welding. After assembling the shell and furnace the door openings were cut out with the oxy-acetylene flame. The door ring of quarter-inch plate was formed of the proper size, 10 by 11 inches and welded, after which it was set in place and welded inside and out.

The inner drum was assembled and welded in the usual manner, after which a 1½-inch pipe flange was welded inside the furnace at a point convenient to connect the bottom of the drum with the pipe for circulation, also a 1½-inch pipe nipple was welded to the shell near the top for a connection for a hydraulic test. The tubes were placed in the drum and expanded and beaded in the ordinary manner with an ordinary expander and beading tool.

A hydraulic test of 240 pounds per square inch applied to the drum proved that the job was perfectly tight and strong. A similar test of 200 pounds per square inch applied to the shell section developed slight leakage in certain places, which, however, were quickly rewelded. A vigorous hammer test was applied to all parts of the boiler while under pressure and it resulted in no perceptible defect or weakness.

The question of the commercial value of welding as compared with flanging, riveting and calking, could not, in the writer's opinion, be taken seriously in favor of either side with the present information at hand, yet it is very likely that for small shops which do a miscellaneous line of work this



SECTIONAL VIEW OF WELDED BOILER.

apparatus can be used to a good advantage in many ways with only a small or moderate cost for shop tools and labor. The points described in this article would certainly not furnish sufficient data as to actual cost of this process when used commercially, as the design of the boiler, like many others, could be simplified to leave less welding surface. However, forming blocks and additional shop labor is to be considered.

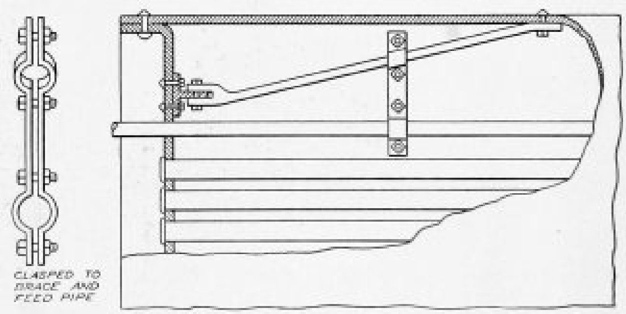
Plate of ¼ inch thickness appears to weld very nicely; no doubt heavier material could be worked to better advantage with additional heat applied and the result would very likely be a more economical consumption of gas. The writer will endeavor to keep in touch with this new process of welding so as to be able to inform the readers of THE BOILER MAKER as to its practicability and the extent of its use in this vicinity.

The photograph gives a very good idea of the ease with which this kind of work may be performed. The apparatus consists principally of a small brass blow-pipe which can be easily handled in one hand, as it weighs only about 2 pounds. This blow-pipe is connected by means of rubber hose or tubes to the oxygen supply and also to the acetylene generator. Suitable safety valves are arranged to prevent a drop in pressure of one of the gases, causing the other to fill the tube and cause an explosion. The gases are not mixed until they arrive at the blow-pipe. The temperature produced by the flame is said to be about 3,000 degrees F., or perhaps more. This flame is directed on to the parts to be welded and, as it is small, heats only a small portion of the plates in the vicinity of the weld. Its high temperature quickly raises the temperature of the plates to the melting point, and as a small bar of steel is held on the junction of the plates, which are being welded at the same time, this bar is melted drop by drop and united with the plates, joining them together.

The proportion of oxygen and acetylene can be varied to obtain the temperature best suited to the work. The appearance and character of the flame vary somewhat with the mixture, so that it is easy to see just by watching the flame when the best heat is being obtained. This is a peculiar characteristic of the oxy-acetylene flame and one which is not found in blow-pipes using ordinary gas or hydrogen. Of course, it is necessary to carefully guard the eyes of the operator, since the flame is very brilliant.

Overcoming a Leak.

A leak developed in a horizontal tubular boiler at the point where the feed-water pipe went through the boiler head. The feed-water pipe was a 1½-inch brass pipe, which passed through the boiler head about 4 inches above the tubes. The hole for this pipe in the tube sheet was 2 inches in diameter and tapped for a 1½-inch brass bushing. The pipe extended 14 feet inside the boiler towards the back head and then passed over the side and down below the water line. The bushing in the front head leaked badly, although the boiler was new and everything should have been tight.



THE FEED-PIPE WAS CLAMPED TO A DIAGONAL BRACE.

All efforts to stop the leak were of no avail, until finally the boiler inspector advised getting two flat pieces of iron, which could be clasped one end around the feed-pipe and the other around one of the braces, as shown in the illustration. The brace took off the pulsation of the feed-water pump, and it was found that the leak stopped in a short time.—X. D. Tolles, *Chicago Engineer*.

A unique method of transporting a boiler was resorted to in the case of one sent to New Mexico by the Kingsford Foundry & Machine Works, Oswego, N. Y. The boiler was of the cylindrical marine type, designed for 150 H. P., and the roads were so soft that they would not support wagons with such a load. By rigging a pipe through the furnace for an axle the boiler was rolled 9 miles over and around the mountains.

Some Remarks on the Design, Construction and Working of the Marine Boiler.*

BY RICHARD HIRST.

In bringing this paper before the society the writer wishes it to be understood that it is not his intention to put forward anything novel, but simply give a few opinions upon the practice of boiler construction which has come under his notice during a long experience.

Boiler construction during the last twenty years has greatly improved, and has permitted the increased pressures now adopted. The improvement is due to the superior machinery available, the quality of steel as compared with iron, and the greater care taken in the workmanship, punching being now nearly a thing of the past, and drilling becoming almost the rule. In the old days boiler plates were made under the steam hammer from faggoted iron scrap, and as they were small, a much larger number had to be used in the building of a shell than is the case to-day. The introduction of heavy rolls has permitted a greatly increased width of the plates to be made (some mills being capable of rolling plates 13 feet wide, and of great length); very often a single-ended boiler shell is now made with only two plates in the shell. In the early days of thick shell plates it was the practice to heat them to a cherry red before bending, and in many instances the furnaces in the shops were not long enough to take in the whole length of the plate; therefore, about three parts of the length would first be furnaced and the other part furnaced afterwards. One such instance caused a rupture in the shell at the point where the two heats met; the shell failed under the water test, and opened out about 3/16-inch the full width of the plate. Cold bending was then resorted to in vertical rolls, and with less liability to any twist taking place in the bending or setting up strains by unequal heating. The first thick plates bent cold that came under my notice were bent in horizontal squeezers with concave and convex surfaces, great care having to be taken by marking off the parallel lines to avoid twisting, and in order that the butt joints should be fair.

On the introduction of the vertical rolls there was less chance of twisting, the rolls being set at right angles to the surface plates; large plates are very easily handled in most shops, and the great advantage of doing away with the center seam and keeping the joints away from the boiler bottom tends to lengthen the life of the boiler. Vertical squeezers are now largely used. They permit the curvature being correctly made right up to the ends of the plate. This is not possible with rolls.

Where the width of the plate can be made to take the length of the boiler, the butt straps are the same length; but in the case of double-ended boilers it is not so, and where the points have to be broken it is good practice to fit the straps under the next strake, taking the first or outer row of rivets in the circumferential seam. Some makers butt them up close to the next ring and fit an outside cleat or patch, which has an ugly appearance. Now with regard to the riveting: the percentage strength of the joint should be about equal, but any difference of strength ought to favor the riveting; *i. e.*, say the plate has the strength of 86 percent, the rivets should not be less than 87 percent, care being taken that the holes are full. A slight fin left beyond the heads, showing that no more metal could be got in the holes, is not an eye-sore, and a sure sign that long enough rivets are being used. When riveting shells under a hydraulic riveter they become hot at the part being riveted, and should be allowed to cool by turning the shell, and the work proceeded with at another part whilst the other portion is cooling, as by so doing sounder work will result.

Where compensating rings have to be fitted, all such rings should be riveted on the shell before the holes are cut out, and this often prevents subsequent ruptures. All man-hole doors should be a good fit in the apertures; in fact, as neat as a piston in a cylinder. The plates of the doors should be sufficiently thick to prevent buckling under pressure. The load on a 16-inch by 12-inch door at 160 pounds is about 10½ tons. Where flanged necks and domes are fitted, care should be taken that the plates are of sufficient thickness to prevent any bending action. In a case which came under the writer's notice, when the valves were being adjusted, the dome moved on the neck portion quite readily, owing to the thinning of the plate in flanging. Brackets were afterwards fitted to keep the dome in position.

When drain cocks or drain bolts are fitted, brass plates and plugs are not good for the plating, as they set up galvanic action and destroy the shell plating, and have been the cause of several men losing their lives. The big-headed bolt, fitted from the inside, made of iron and nutted outside, is the best drain arrangement.

When the end plates are flanged in the ordinary way, tightness under steam depends upon the flanging and plating where the lower front, tube and upper plates come together. Good fitting is necessary. If they could be turned in a lathe, good surfaces would be obtained; then if efficiently riveted in place, less calking will be required. End plates are left with much deeper flanges than used to be the practice. The advantage is a better attachment, as the circumferential seams at those parts are not so near the face of the ends, and can be much more readily calked.

Flanges for furnace mouths are generally bored out true. This does not prevail everywhere, but there is no doubt that it improves the work. Tube plates when being drilled should have good, smooth surfaces in the holes, and before being taken off the drilling machine each hole should have a coating of oil to prevent any rust depositing before the plates are used. The oil must be cleaned off before the tubes are rolled in. There are now a great number of styles of furnaces in use besides the original plain ones. These are made in several different ways, but the Fox, Morrison and Deighton are first lap-welded in plain plates and afterwards corrugated in the rolls. Most of the other types are first ribbed or corrugated, and then bent in the circle and welded. In passing, I would remark that the portion to be flanged should always be taken from the bottom part of the ingot, and when two plates are taken from one ingot the center or nearest bottom portion is the flanged end, which, in some cases, is rolled ⅛ inch thicker at that end, to allow for any wasting that may occur in flanging.

Some boilermakers weld the furnaces to the back tube plates, whilst others thin the tube plates at that point, more especially when the bottle-neck furnaces are fitted. As most of you are aware, some years ago a great number of furnaces failed at the back ends at the return flange. The writer was at that time instructed by the committee of Lloyd's Register to visit the works of the different furnace-makers, with instructions to pay particular attention to the flanging process. It was then found that the radii at the corner and back ends were very small, so small, in fact, that the blacksmiths, to get them into the required shape, had to fuller them to such an extent and take heat upon heat that it was no wonder they failed and cracked under working conditions. Some of them were almost cut in two before leaving the several works. This was not the fault of the furnace-makers, but of the engineers who designed them. Failures at these particular corners are now a very rare occurrence.

More care is taken in the plating of the combustion chambers, and larger radii are used at the bends of the tops and sides than used to be the case. In some works, after

* Read before the Mersey Foremen Boilermakers' and Iron Shipbuilders' Association, Liverpool, England.

flanging, the surfaces are either filed or ground at the corners, and sometimes over the whole of the flanged surfaces, taking out the hammer marks, and this brings the two surfaces much closer together, making sounder work possible.

The combustion chamber bottom plates should always be amply thick to allow for the wasting at those parts; doubling plates should never be fitted in combustion chamber bottoms. One case came under the writer's notice where the inside plate had buckled considerably between the rivets, while the lower or steam-side plate had not altered its curve. The inner plate got overheated, and the steam had got between the two plates and set out the one on the fire side, with the result above mentioned.

It may not be out of place to describe how the tubes are made before dealing with the fitting of them. Strips of plates are rolled the requisite length and width, and are then bevelled on the edges at opposite sides. They are then furnaced, and when sufficiently hot are brought out and passed between two rolls, which are each grooved to the half circle, and work in a vertical position. The leading ends, *i. e.*, the ends that first enter the rolls, are partly folded inwards, and as the tube enters the roll it is received upon a mandrel, shaped somewhat like a boy's spinning top. The mandrel is about 6 inches long, and is placed just between the grooved rolls, and into the flat end is screwed a long rod, the tube being pushed over the mandrel. The weld is then completed the whole of the length by this one passage through the rolls. The tubes are then laid on surface plates and straightened or turned, such treatment being all that is required for making and fairing except cutting for length.

The Serve tubes are made in a similar way to the above description, with the exception that the ribs are rolled in the plates instead of being left plain. The ribs are on both surfaces until the last passage between the rolls, then the opposite rib is crushed into its fellow, which leaves one surface plain and the other ribbed. The reason that this method is adopted is because it would be impossible to commence at first with the plain and ribbed surfaces unless the provision was thus made for the surplus material that must accumulate between the ribs. The plates are then bevelled on the edges, and treated similar to the plain tubes, only the mandrel is grooved to receive the ribs. The process is not as simple as in the case of the plain tube, a number of them being spoiled when they were first being made by the men failing to catch the ribs direct into the grooves in the mandrel. Before fitting tubes into the boiler some firms grind the scale off both ends at the fitting parts, which is a good thing, bringing the surfaces closer together than would be if the scale was left on. All plain tubes should protrude sufficiently far through plates to admit of them being driven back when it may be necessary beyond the face of the back plate. Some makers bead them at the back ends, and others leave them plain. It is a matter of opinion which is the best, but when headed over there is less surface for deposit.

Stays are now almost all made of steel. It is the writer's opinion that good iron is the best material for the screwed stays, but for the large stays steel is best. Less diameter, and, of course, less weight, is necessary than if made of iron. Taking first the large stays, it was difficult to keep them tight under steam when first high pressures came into practice, and very often they were screwed into both end plates. Again, the holes were slightly countersunk, lead rings and cement filled in underneath the nuts, but what did more to prevent the leakage was the setting hard up of the inside nuts before tightening up the outside ones. Perhaps the best bar stays are those with the ends crushed up, the bottom of the screw threads being the same section as the body of the bar, care being taken that the inside nuts will slip along the bar without a great amount of dressing. Care should also be taken in screwing the ends, as, unless the dies are good, steel crumbles and will not close the same as iron, very often leaving broken threads. Iron is, in my opinion, better than steel for the smaller stays, because I consider they are less liable to snap suddenly. They have a longer life, and the corrosion in iron is not so short and acute as in the case of steel. With the drilling and screwing machines now in use better work is done, and nothing looks better than even length of stays and protuberance not more than a thread through the nuts. Some firms insist on a very small hole being drilled in the end of the stays just beyond the thickness of the plates, as this acts as a tell-tale when the stay gives way; but, of course, all such work costs money. Girder stays should be fitted sufficiently clear of the tops and made to take both vertical and crown plates at the same time, and not project beyond the thickness of the vertical plates, where they prevent scaling by the overhang. When the boiler is subjected to the hydraulic test, care should be taken to let down the load gradually in pounds as it was put on, and not to take it off in tons, more damage being done by such sudden lightening of the load than twice the working pressure will ever cause. When subjecting boilers to test after repairs, one and a half working pressures is sufficient test to find any defective work that may exist. Where the pneumatic calking machine can be used, neater work can be done; but with good plating less calking is required, and the less the better.

Double-ended boilers, to suit certain conditions, are still frequently used, and are quick generators of steam; but in the past they have not been altogether a blessing, racking, as they do, the furnace ends, especially when the combustion chambers are common, causing the landing edges of the seam to crack from the rivet holes, and the flanges at the furnace ends to split. Separate combustion chambers are, in the writer's opinion, the best design, and less liable to rupture at the parts mentioned. When the end plates are flanged out the heel of the flanges should be set back; tighter work is obtained, as the plates are easily closed under the riveting machine.

With regard to double-ended boilers, when the punching of shell plates was general, and the pitching of the riveting not so carefully thought out, the plate section was often reduced to such an extent that the shell of these boilers very often split between the rivet holes, several such cases having come under the writer's notice. One instance was where the crack extended 8 feet 3 inches circumferentially, and was repaired as follows: The rivet heads of the original seam were left in, but cut off flush and closed as far as possible, and the square edge of the landing bevelled away; a large joggled plate curved to about an inch less radius than the boiler bottom, lapping the seam about 1 foot each edge, was fitted, with a single row of rivets at each edge about 4 inches pitch, and when fitted it was pumped up with a solution of boiled oil and lead. The boiler bottom was not otherwise disturbed. By cutting out the defective plate the boiler would have been considerably weakened. Such repairs have never given trouble excepting where the bottoms have been cut out. Front and back end seams when flanged outwards often waste through leakage, and can be made tight if sufficiently high to get a blow at the rivets. First cut out the original rivets and dress the edges of the plates as far as practicable, and then bend a round bar the same diameter as the thickness of the end shell plates to the same radius as the boiler; flange the plate to the shape of the molded bar, thus stepping the rib of the seam, and make the plate sufficiently wide to take hold of the boiler bottom and end plate—say for a distance about 1 foot vertically on the back end, and the seam longitudinally on the shell. Longer rivets will be required, but the new rivets in the patch will form part of the circumferential seam. Smaller rivets can be used at the edges of the patch, and this has been proved an effective repair. When the ends are flanged inward in the ordinary way, and wasting of plates and rivets has taken place, making it necessary to cut out the fronts, scarphed landings are better than butt straps, and should be double riveted if possible. The wasting of front ends is usual in boilers placed too low, through the cooling out of ashes when cleaning fires, the flanged plates being more vulnerable to corrosion than plates which have not been worked in the fire. Wasted rivets in the bottom of the circumferential seams are often found to be worst at the back of the seams, the heads facing the man-hole being as good as the day they were put in. This is caused by heavy iron rakes being dragged over the heads when the dirt and deposit are being cleaned out, and, therefore, wooden rakes should be used. It must not be forgotten, however, that one great advantage of the Scotch boiler, is the room in the bottom for deposit.

We find furnaces pitted the worst at the line of the bars. This is due in some instances to narrow water spaces, but very often to neglect in keeping them clean, causing them to crack. Doubling used to be common in such cases with plain furnaces, and this not only increased the liability to further cracking, but always meant renewal of furnaces. Where half-angle bars are fitted too high and the ends come into the bed of the fire the same thing happens. The furnaces split away from the rivet holes of the angle bars. Where it is possible to repair a damaged plain furnace the patch should be fitted on the fire side, so that when it is renewed in most cases the same size of patch will do. When they are fitted on the steam side the landing edge of the furnace is burnt away, and this means a bigger patch at each repair. Few of the patent furnaces can be repaired with any satisfaction.

Combustion chambers waste more at the bottoms and lower back ends, and this is due to the deposit left in when the boilers have been blown down. Instances have occurred of such wasting, due to the feed-water impinging on the upper backs and sides, and frequently around the necks of the stays small cavities of corrosion will often be found. It has often occurred to the writer that a great deal of this corrosion could be prevented if the combustion chamber bottoms were cleared of the hot deposit when the boilers were blown down or run out. Grooving is sometimes found at the landing edges of combustion chambers, and one such case recently was the cause of all the combustion chamber having to be entirely renewed. The deep center boxes were fitted in three plates, and the wings in two at the backs, whilst the sides were fitted in two plates, and the bottoms each with one plate, care being taken that the landing edges of the riveted seams were placed so as not to catch the flame. Every screwed stay was renewed. These repairs were done without taking out any of the furnaces or tubes, the boilers being single-ended. In another case of repairs to a double-ended boiler which had been leaking so badly that the vessel was towed in from sea, the writer found the flanged corners at the furnace ends sprung to such an extent that he could insert his fingers. The firebox was common to both ends, and all the rivets at the sides were leaking, and a great number loose. The tube plates were buckled and the tube holes oval, some of them ¼-inch, and the crown plates were buckled. This case was repaired by cutting out all the tubes, rivets, crown stays and plates, the latter being badly buckled. Spectacle tube plates were made with holes larger than in the original, and all the holes in the tube plates were faired. This was done to prevent the rosebits getting away from the truth. The crown plates and all the riveting were renewed, as were the ordinary and stay tubes. The repair was done without cutting out the furnaces.

In the raising and lowering of steam pressures, time and care should be taken. All grease and fatty matter should be prevented from entering the boiler, and all scale-preventing and cleaning compounds avoided. Leakage, be it ever so small, often gives trouble, and the writer has a case in mind, when the compound engine was first introduced, of an able engineer who had been used to the jet condensing engines having drilled small holes, about 3/16-inch diameter, opposite the port in the blow-down cocks. By so doing he thought to avoid scumming by opening the cocks in the usual way. The result was that, at the end of a long voyage, he found the boilers just like salt pans, and all the backs buckled and the tubes leaking. In another case six Cornish land boilers, which were fed from a tank into which several factory engines exhausted, the furnace of the one nearest the tank collapsed with 10 inches of water in the glass. When the boiler was blown out nothing but a fine dust was observable. The boiler was put into use again, and the furnace collapsed as before. It was then decided to cut off the feed tank, with the result that there was no further trouble. This clearly proved that the fine dust which was first seen must have been highly charged with grease. The majority of cases where furnaces have collapsed are due to greasy deposit, and in many instances have occurred after the boilers have been under banked fires. They are caused by the grease settling on the furnaces, which had previously been held in suspension when under steam. It is the writer's opinion that frequent washing out of boilers, the use of zinc plates, common soda, and sometimes a small quantity of lime, will keep a boiler healthy.

Patches have recently been fitted to boilers by means of welding, known as oxy-acetylene process. Mr. Ruck Keene, a colleague of mine, has read a paper on the system. This form of repair may accomplish what ordinary calking cannot cure; but, in my opinion, boilers treated by such a process must always be regarded with a certain amount of suspicion, and should be kept under very careful observation.

Renewing Tubes in a Horizontal Tubular Boiler.

BY J. E. SEXTON.

While the renewal of boiler tubes is properly the work of the boiler maker, the engineer who knows how to and can do it is just so much more valuable to the employer. The purpose of this article is to describe the method employed by the writer, together with the tools required.

First, it is essential to place a distinguishing mark on the front and rear heads to show which tube is to be cut out, using chalk or soapstone for the purpose, and the best way to make sure that the helper at the other end of the boiler marks the same tube that you do is to run through a strip of wood 4 or 5 inches longer than the tube. As such a strip is of use farther along in the process I make a length of ⅞ by 2-inch pine to serve both purposes. Next, with a hammer and a heavy cape chisel having a wide cutting edge, which is less liable to cut or mar the boiler (see Fig. 1), face the beads on both ends of the old tube until they are flush with the heads of the boiler. Then, at the front head, with a diamond-point chisel such as is shown in Fig. 2, cut a slot or channel, 1/16 inch wide, in the bottom of the tube extending inward to about ⅜ of an inch beyond the inner edge of the head, making sure that the groove is cut in the tube only and that the head is not cut or even marked by the chisel. Do not drive the chisel clear through the tube, either.

With an offset chisel, Fig. 3, carefully turn up the edges of the tube at both sides of the cut, until the tube-end resembles the condition shown in Fig. 4, when it will be found that this end of the tube has been released from the head. In cutting the slot, especially after the cutting edge of the chisel has gone beyond the thickness of the head, if the chisel is allowed to go through the tube it will be the source of considerable trouble, as it will cause the tube to spread. Hence, at this point extreme care must be used.

If a tube is corroded and muddy, it will be harder to remove and the method will have to be changed somewhat. Considerable force is required sometimes to remove such a tube. Instead of one slot in the bottom of the tube, two are

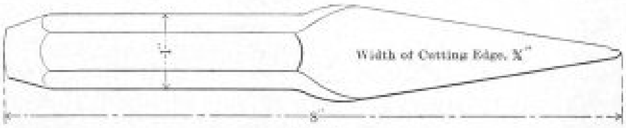


FIG. 1

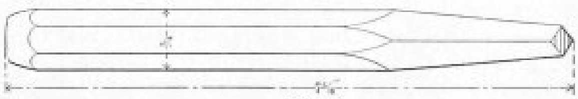


FIG. 2

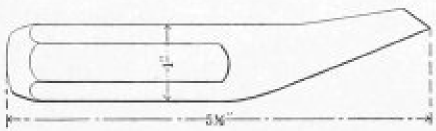


FIG. 3

cut, about ⅜ of an inch apart, and the offset chisel is used as before, except that the ⅜-inch piece is turned up until it looks like the letter C, with its back toward the front of the boiler. Then proceed as before, turning the edges of the cut upward as far as they will go. A hook on the end of a chain or rope may then be inserted in the loop formed by the C-piece. This takes care of the front end.

At the other end of the tube insert the end of a piece of shafting about 10 inches long and a little smaller in diameter than the outside diameter of the tube. The end of this shafting should be turned so that it will enter the tube about one inch, with an easy fit, and by giving a few taps on the outer end of this improvised mandrel the tube will be loosened at this

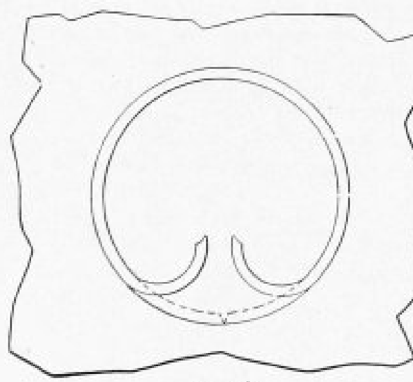


FIG. 4.

end. Then, by working the tube backward and forward it can be released altogether.

The next step is to mark the new tube so it can be cut to length. Insert the ⅞ by 2-inch piece of pine into the holes the old tube came out of until one end of the strip extends through the rear head about 5/32 of an inch. Hold it there and proceed to place a mark on the end extending from the front head 5/32 of an inch from face of the head. This gives the proper length to which to cut the new tube. Then, while the tube is being cut to length, take a half-round second-cut file, or a finish-cut file, and carefully smooth up the heads around the holes, removing any marks or cuts which may have been made in taking out the old tube. This is to prevent future leaks. Next, push the new tubes into place and station the helper at the rear end with a tube expander, being sure that the ends of the tube are equidistant from the heads. It is advisable to insert one end of an 8-foot section of 1-inch pipe in the front end of the tube, for a distance of 12 inches or so, and exert a downward pressure on the lever so provided to prevent the tube from turning

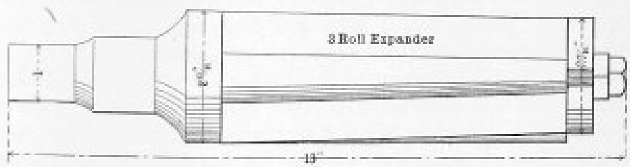


FIG. 5.

while the rear end is being expanded. As soon as the tube is tight at the rear end, proceed to expand the front end.

A self-feeding expander, Fig. 5, will give good results, especially if a ratchet wrench is used to turn the spindle, for one can tell by the feeling just when to stop expanding. A monkey wrench will do, however, if a ratchet wrench is not available.

The beading comes next. This requires a special tool similar to that shown in Fig. 6. Place the long prong of the tool inside the tube, with the short prong pressing against the tube-end. Then bead the tube-end thoroughly throughout the

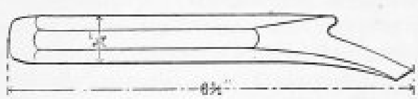


FIG. 6.

circumference, for if it is only beaded here and there it will prove very unsatisfactory. When both ends are beaded, use the expander lightly in each end once more, to remove the marks made by the beader.

If both hand-hole plates are tight and the blow-off valve works O. K., fill the boiler with either hot or cold water until the tube is covered, and if the tube does not leak water it will hold steam, and the boiler is ready to put into commission. If the tube leaks, re-expand it very lightly. Ordinarily, a man and helper can renew a tube in an hour with ease.

—*Power.*

Layout of a Double Angle Pipe from the same Miter Line.

BY JOHN E. LANDIS.

First draw the plan with an angle of 38 degrees, 48 inches off the center and 116½ inches long. Now project the elevation with a rise of 30 inches, with the center of the miter line in the same plane as the center of the miter line in the plan.

Place the miter line of the elevation *A* as at *A'*, so that the points 1-9 are in the same line as 1-9 in the plan; then project the lines up in the plan until 1 intersects 1, 2 on 2, 3 on 3, etc. Where these lines meet gives the line of intersection. Now we can lay off the patterns for both end sections.

Space off the sheet into the same number of parts as the circles. Draw lines from the line of intersection over to the pattern. The other line of intersection *B* is found in the same way as *A*.

Now we will find the true length between centers of the miter lines, as both the plan and elevation are foreshortened views.

$$(60)^2 + (48)^2 = 3{,}600 + 2{,}304 = 5{,}904.$$

$$\sqrt{5{,}904} = 76.81 \text{ inches.}$$

This gives the length of the plan.

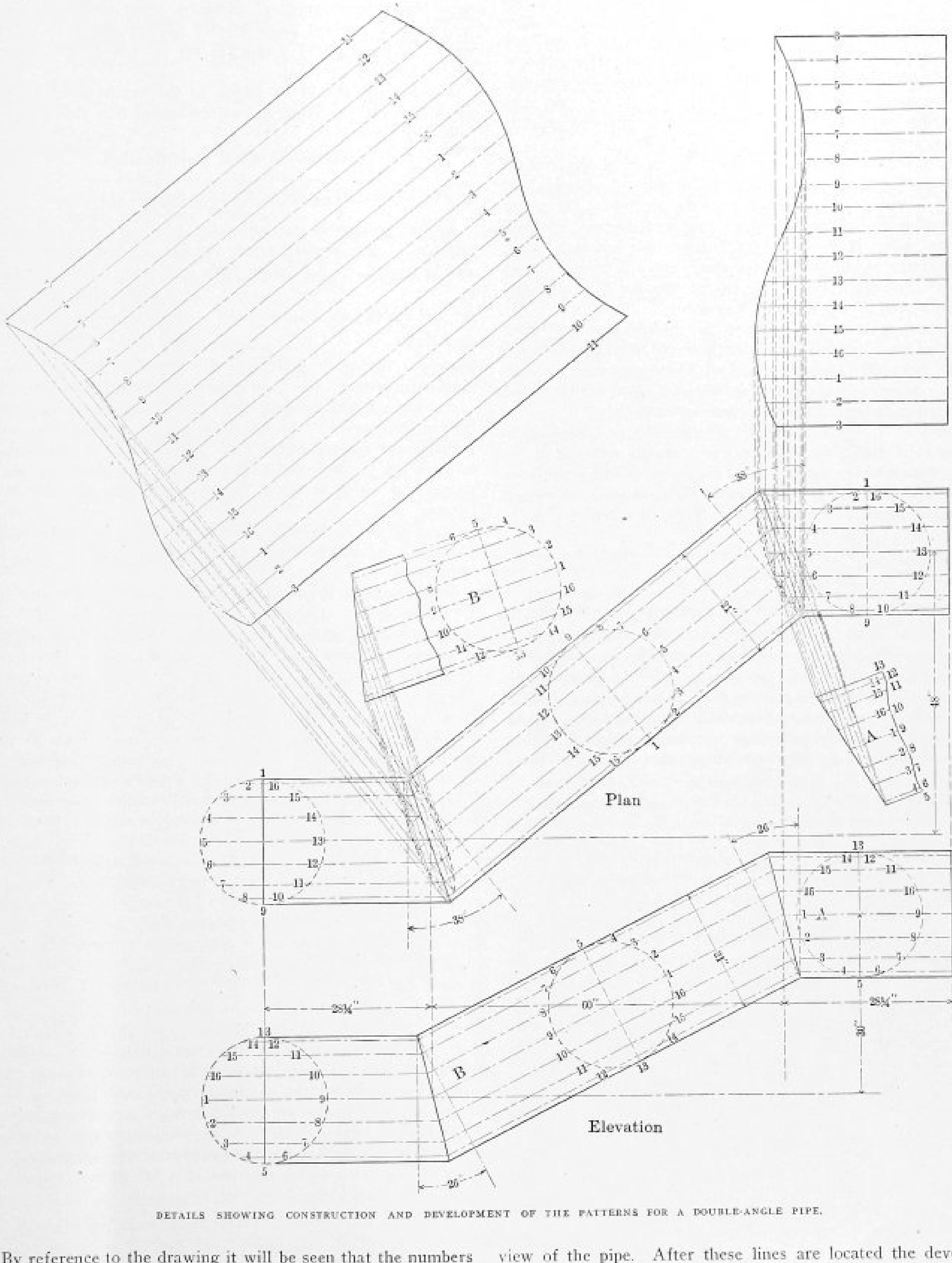
Now we will find the length of the elevation.

$$(76.81)^2 + (30)^2 = 5904 + 900 = 6{,}804.$$

$\sqrt{6{,}804} = 82.5$ inches as the length of the center part between centers.

elevation. The details of the remainder of the layout are clearly shown in the drawing.

Of course the main difficulty with this layout is the proper location of the lines of intersection at each end of the plan



DETAILS SHOWING CONSTRUCTION AND DEVELOPMENT OF THE PATTERNS FOR A DOUBLE-ANGLE PIPE.

By reference to the drawing it will be seen that the numbers have been moved around half way. This is done to bring the high part in line with the lowest part, or so that they would be in the same relative position as they were in the plan and view of the pipe. After these lines are located the development is carried out in the ordinary manner for cylindrical surfaces. Care must be taken to keep each line numbered or lettered with the same character in each view.

Estimating the Cost of a Small Scotch Boiler.

BY JAMES CROMBIE.

In the March number of THE BOILER MAKER the writer described the method of estimating the cost of repairing a small Scotch marine boiler in which the crown sheet and back of the fire-box had buckled, due to low water. It was found that to make the necessary repairs would require an expenditure for material and labor amounting to $135, and that after the repairs were made the boiler could be allowed only 43 pounds working pressure.

In the present article an estimate is made of the cost of building an entirely new boiler of the same dimensions but capable of carrying 125 pounds working pressure. The boiler is 42 inches in diameter, 84 inches long, and contains one furnace 22 inches in diameter and twenty-three 2½-inch tubes. The segment of the heads in the steam space is braced by two 2¼-inch through stays. The top of the fire-box is stayed from the shell of the boiler by stay-bolts.

The first thing to do is to find the thickness of shell plate necessary to withstand a working pressure of 125 pounds per square inch. The British Board of Trade and the Canadian Marine Rules, which are almost identical, give the following formula for the strength of a cylindrical boiler shell:

Where D = inside diameter of the shell in inches; t = thickness of shell plate in inches; f_t = tensile strength of the plate in pounds per square inch; P = safe working pressure of steam in pounds per square inch; E = efficiency of riveted joints (the least to be taken); F = factor of safety.

$$\text{Then } t = \frac{P \times D \times F}{2 f_t \times E}$$

Assuming a double riveted lap joint with an efficiency of 70 percent and a factor of safety of 5; then $t = \dfrac{125 \times 42 \times 5}{2 \times 60{,}000 \times .70}$ = .3125, or 5/16 inch.

If the holes are all punched small and afterwards reamed out fair, the plates taken apart and burrs removed, then a factor of safety of 4.5 may be used. In this case the working pressure $P = \dfrac{2 \times .3125 \times 60{,}000 \times .7}{42 \times 4.5} = 138.8$ pounds.

The boiler would be allowed 125 pounds pressure if ¼-inch plate were used with double riveted butt straps; but in this estimate 5/16-inch plate will be used with a lap joint.

The size of the shell plate can now be determined. Its width, of course, is equal to the length of the boiler, 84 inches. Its length is equal to the circumference of a circle the diameter of which is measured to the center of the thickness of the plate. The inside diameter of the boiler is 42 inches, and the thickness of the plate is 5/16 inch. Therefore, the mean diameter is 42 5/16 inches. The circumference corresponding to this 42 5/16 × 3.1416 = 132 15/16 inches. Allowing 4½ inches for the lap and waste in trimming, the actual size of the shell plate is 132½ by 84½ by 5/16 inches. The weight of a cubic inch of mild steel is .2833 pound. Therefore, the weight of the shell plate equals 137.5 × 84.5 × .3125 × .2833 = 1,029 pounds.

Having determined the size and weight of the shell plate, the next item is the furnace and the main flue. The Canadian Marine Rules on furnaces and flues are as follows:

$$\text{Working pressure} = \frac{C \times t}{(L + 1) \times D}$$

Where t is the thickness of the furnace in inches; L the length of the furnace; D the diameter of the furnace, and C a constant determined as follows:

C = 90,000, when the longitudinal seams are double riveted and fitted with single butt straps, or single riveted and fitted with double butt straps; C = 65,000, when the longitudinal seams are lap jointed, single riveted and beveled; C = 60,000, when the longitudinal seams are lap jointed, single riveted, punched and not beveled.

Ten percent should be added to the result given by the above formula, providing it does not exceed that found by the following formula:

$$\frac{9{,}000 \times \text{thickness of plate in inches}}{\text{Outside diameter of flue in inches.}}$$

As the furnace in the boiler for which we are giving an estimate is only single riveted, and not beveled, the constant will be 60,000. Using a plate 33/64 inch thick for the furnace, we find for the working pressure $\dfrac{60{,}000 \times (33/64)^2}{(5.25 + 1) \times 22} = 116$ pounds. Adding 10 percent to this gives 127.6 pounds as a working pressure. As we are building a boiler to withstand only 125 pounds, it will be seen that a furnace or main flue 33/64 inch in thickness will be sufficiently strong. Other rules will probably not require such a thick plate, and as it is desirable to have the furnace wall as thin as possible consistent with strength, it would be better to use a 7/16-inch plate for this purpose.

The size of the furnace plate would be 72 by 65 by 7/16. Therefore, its weight would be 72 × 65 × .4365 × .2833 = 580 pounds.

The back head before flanging is 47 inches in diameter by 5/16 inch thick. Therefore, its weight would be $(47)^2$ × .7854 × .3125 × .2833 = 154 pounds. The front head is also 47 inches in diameter, but would be ⅜ inch thick. Therefore, its weight = $(47)^2$ × .7854 × .375 × .2833 = 185 pounds. The tube sheet is 41 by 32 by ⅜ inch, and would weigh 139 pounds. The back of the fire-box is 41 by 32 by 5/16 inch, and would weigh 116 pounds. The sides and crown of the fire-box could be made from a plate 114 inches long and 15 inches wide by 5/16 inch thick, which would weigh 151 pounds. The total weight of plate used in the boiler may now be summed up as follows:

	Pounds.
Shell plate	1,029
Furnace	580
Back end of boiler	154
Front end of boiler	185
Tube sheet	139
Back of fire-box	116
Sides and crown of fire-box	151
Total	2,354

It will be noted from the illustration that in the original boiler on which repairs were made there were only two through stays supporting the heads in the steam space. The total area to be supported in each head is 220 square inches, or 110 square inches per stay. It is now necessary to find what working pressure these stays are capable of withstanding. The formula for the working pressure of a flat surface stayed at regular intervals is:

$$P = \frac{C\ (16 \times t + 1)^2}{S - 6}$$

Where t = thickness of plate in inches; S = surface supported by one stay in square inches; P = working pressure in pounds per square inch; C = a constant (in this case 125).

Substituting as follows in the above formula we have:

$$\frac{125\ (16 \times .3125 + 1)^2}{110 - 6} = 43 \text{ pounds working pressure per}$$

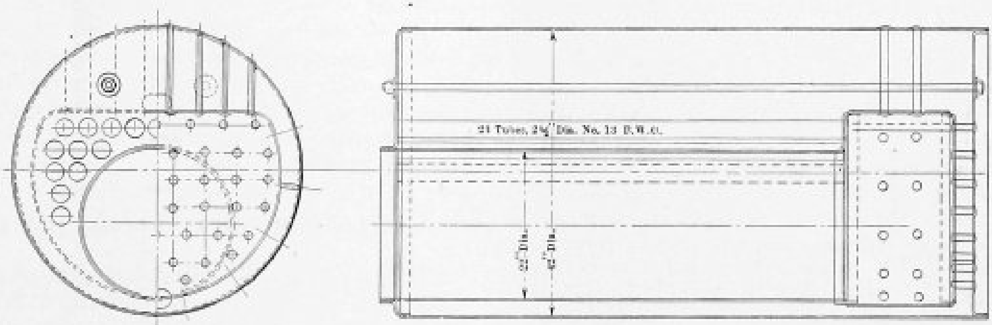
square inch; 43 pounds per square inch is then the highest working pressure that could be carried on the old boiler after it was repaired, unless additional stays were placed in the steam space.

Solving for S, the area to be supported by one stay at 125 pounds working pressure, we find $S = \frac{125\ (16 \times .3125 + 1)^2}{125 + D}$ $+ 6 = 42$ square inches. The diameter of the stay rod may be found from the following formula:

Let d = least diameter of stay in inches; t = area supported by one stay in square inches; P = working pressure in pounds per square inch; K = constant; f = safe stress allowed on one stay in pounds per square inch.

$2.50. As there are seventy-two holes to be punched in each end of the shell plate, and sixty-five for the longitudinal seam, the total number of holes to be punched in the shell plate is 274. The punch would average about five holes per minute, so that the plate could be slung and punched in one hour. Cost, one puncher one hour at 17 cents; two helpers, one hour each at 15 cents; total, 47 cents. Shearing the inside of the lap joint, turning over the plate, beveling three edges in the bevel shears, turning over the plate again, thinning out two inside corners of the plate at the fire, and then rolling up the plate would take one boilermaker an hour and a half at 24 cents per hour; two helpers one hour and a half each at 15 cents; total cost, 81 cents.

In the furnace plate there are 140 holes to be punched, which would take one puncher one-half hour, two helpers one-half hour each, making a total cost of 23½ cents. Beveling the two ends, thinning out two corners of the plate at the fire and rolling up would take one boiler maker one hour; two helpers one hour each; making the total cost 54 cents.



SMALL SINGLE FURNACE SCOTCH BOILER.

Value of K =	.0168	.0160	.0146	.0140	.0135	.0130	.0126
f =	4,500	5,000	5,500	6,000	7,000	7,500	8,000

Wrought iron stays, made from solid bars, which have not been worked in the fire, are allowed a stress of 7,000 pounds.

Therefore, from the preceding table, $K = .0135$. The formula is $d = K \times \sqrt{P \times A}$. Solving, $d = .0135 \times \sqrt{125 \times 42} = .978$ inch.

Therefore, the least diameter of the stay, or the diameter at the bottom thread, must be as great as .978 inch. A 1¼-inch screw stay, seven threads to the inch, is 1.067 inches in diameter at the bottom of the thread. It would be necessary to use five of these with double nuts and washers, the washers to be at least three times the diameter of the stay and two-thirds the thickness of the plate. Stay bars, 1¼ inches diameter, 36½ feet long at 4 pounds per running foot, would weigh 146 pounds. The balance of the total cost of the material for the boiler is, therefore, as follows:

146 pounds of stay-bar iron at 2 cents a pound........	$2.98
10 pounds of nuts and washers at 2½ cents per pound...	.25
126½ feet, 2½-inch diameter, tubes at 15 cents per foot..	18.98
110 pounds of rivets at 3½ cents per pound............	3.85
82 stay-bolts (70 pounds) at 2 cents per pound........	1.40
3 handhole doors with covers........................	3.00
3 gaskets for handhole doors.........................	.30
2,354 pounds of plate at $2.10 per hundred pounds.....	49.43
Total cost of material for new boiler............	$80.13

We will get an estimate of the cost of labor by taking up each operation in turn and finding how many men will be required to do each part of the work and how long it will take them.

In the first place, laying out the boiler would take one layer-out about ten hours, and at 25 cents an hour this would cost

The plates for the heads are each 47 inches in diameter. Therefore, they can be flanged in one heat. The inner tube sheet and back of the fire-box can also be flanged in one heat; all four plates being finished in three hours, including changing the dies, or formers. The men required would be one boiler maker at 24 cents an hour; three helpers at 16 cents an hour each. Therefore, the total cost for three hours' work would be $2.16. The front end and tube sheet are then marked for the furnace holes. Punching the furnace holes would take one puncher half an hour, and two helpers half an hour each; making the total cost 23½ cents. The front head and tube sheet then go back to the flanger, and the hole is flanged in each plate in one heat; the time for flanging out furnace holes would be one boiler maker an hour and a half; three helpers an hour and a half each; total cost, $1.08.

Punching seventy-two holes around the flange of each head and also the holes around the flange of the tube sheet and back of fire-box, as well as all stay-bolt holes for ⅞-inch stay-bolts and three small hand holes, will take one puncher an hour and a half; two helpers an hour and a half each; total cost, 70½ cents. Drilling forty-six pilot holes and cutting out forty-six tube holes for 2½-inch tubes will take one helper eight hours, at 17 cents an hour; total cost, $1.36. Fitting the tube sheet on the furnace and fitting out the fire-box will take one boiler maker twenty hours; two helpers sixteen hours each; making a total of $9.60. Reaming rivet holes will take two helpers five hours at 15 cents an hour; total cost, $1.50.

Riveting in the front head and the lap joint of the shell on the bull machine would take one handy man two and one-half hours, at 20 cents an hour; one helper two and one-half hours, at 16 cents per hour; and one boy two and one-half hours, at 10 cents an hour. Riveting the lap joint of the furnace around the flange of the inner tube plate, one handy man an hour and a half; one helper an hour and a half; one boy an hour and a half. Riveting the sides and top of the fire-box to the tube sheets, and also riveting up the furnace mouth and back end of the boiler after it is in place would take one handy man two and one-half hours; one helper two and one-half hours; one boy two and one-half hours. The total cost, therefore, for hydraulic riveting would be $2.99.

Riveting the back of the fire-box by hand: two boiler makers three hours each; one helper three hours; one boy three hours; total cost $2.22. Drawing the furnace into the boiler, bolting up, etc., will take a boiler maker five hours and a helper five hours; total cost, $1.95.

The stay-bolt work includes tapping of stay-bolt holes, running in the stay-bolts, setting them and cutting them off, and would require two helpers eight and one-half hours each, at 16 cents an hour; making a total cost of $2.92. Riveting up the stay-bolts would take two boiler makers nine hours each, and one helper nine hours; total cost, $5.76.

Getting the new tubes from the store room and grinding off the sharp edge from one end of each tube would take a boy about an hour and a half, costing 15 cents. Inserting and expanding the tubes would take a boiler maker ten hours at 24 cents an hour, costing $2.40. Inserting five through stays in the steam space would take a boiler maker four hours at 24 cents an hour, one helper two hours at 15 cents an hour; making a total of $1.26.

The remaining work on the boiler includes calking, which one boiler maker could do with an air hammer in ten hours, at a cost of $2.40; testing the boiler with hydraulic pressure, requiring two boiler makers seven hours each at 24 cents an hour, at a total cost of $3.36; also in the stay-bolt work no account was taken of the time necessary for heading and threading the stay-bolts and stay bars. Heading the stay-bolts in a bolt machine will take one handy man half an hour at 22 cents per hour, at a total cost of 11 cents; and threading the stay-bolts and stay rods would take one handy man two hours at 18 cents an hour, at a total cost of 36 cents.

Having determined the number of men required, the time taken and the cost of each operation in building the boiler, we can now tabulate the total cost of labor as follows:

Laying out	$2.50
Punching shell plate	.47
Planing and rolling shell plate	.81
Punching the furnace plate	.23½
Planing and rolling furnace plate	.54
Flanging heads with the hydraulic press	2.16
Punching furnace holes	.23½
Flanging furnace holes	1.08
Punching rivet holes in flanges of heads	.70½
Drilling tube holes	1.36
Fitting up the fire-box	9.60
Reaming rivet holes	1.50
Riveting, hydraulic machine	2.99
Riveting by hand	2.22
Fitting the furnace into the shell	1.95
Tapping holes and fitting stay-bolts	2.72
Riveting stay-bolts	5.76
Grinding tube ends	.15
Inserting and expanding tubes	2.40
Fitting up the through stays	1.26
Calking	2.40
Testing	3.36
Heading stay-bolts	.11
Threading stays	.36
Total estimated cost of labor	$46.87½
Total for material	80.15
Total for material and labor	$127.01

One hundred and twenty-seven dollars and one cent represents merely the cost of material and labor in the boiler, and makes no allowance for depreciation of machinery and other fixed charges. In this case 30 percent of the cost of material and labor will be taken as the amount of fixed charges. This might vary in different shops depending on the kind of equipment which the shop has, the facilities for handling material, etc.

Thirty percent of $127.01 = 38.10; $127.01 × 38.10 = $165.11, the cost of the boiler. To this must be added a certain percentage for profit to get the selling price to be quoted to the purchaser. Allowing 10 percent for profit, the selling price would be $181.62. Therefore, the price quoted for the boiler, exclusive of mountings, such as valves, up-take, etc., would probably be $185.

We found in the article which was published in March that the cost of repairs for this boiler would be $135, so that the difference in the price of the estimates for repairs and for an entirely new boiler is only $50 in favor of the repairs. Furthermore, it should be remembered that even after repairs are made we still have the old boiler, and it is capable of carrying only 43 pounds working pressure, unless extra stays are placed in the steam space. Even then it would not be allowed 100 pounds working pressure, while with the entire new boiler at a cost of only $50 more we have a boiler which could have 125 pounds working pressure.

Explosion of a Thermal Storage Tank.

On Dec. 20, 1906, a thermal storage tank at the works of the South Metropolitan Electric Lighting & Power Company, at Greenwich, England, exploded. It was one of four similar drums, and the circumstances were so remarkable that, after the coroner's inquest on the bodies of two men who lost their lives, the matter was adjourned until further light could be thrown upon the accident by scientific examination of the steel of which the drum was constructed.

The drum was made by Babcock & Wilcox, and was one of a pair connected with one of their boilers; it was used in the

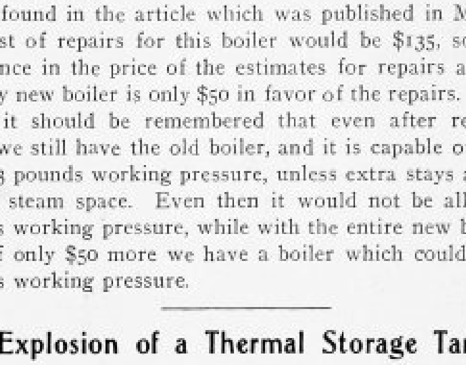


Fig. 1.—The indentations were caused by the blind snap on the riveter.

usual way for supplying hot feed to meet the peak load. It was 5 feet in diameter by 22 feet 6 inches long. It had dished and flanged ends ⅞ inch thick, riveted into the barrel, which was ¾ inch thick. Near the right-hand bottom side of one of the drum ends, and right at the knuckle of the flange, a slight leakage of steam became evident after the boiler had been at work only a few weeks. The leak, on examination, was found to issue from a hair crack 2 7/16 inches long, which was not considered serious by various persons who examined it. It was, however, under observation, and whilst a boiler inspector was examining it the end was blown out of the drum, and the drum itself was projected 95 yards backwards, demolishing two walls in its flight. There were 3 feet of water and 160 pounds pressure in the boiler at the time. The fracture took place circumferentially through the dished end at the knuckle of the flange, and thus a complete disc was blown out. On examination by the Board of Trade inspector the opinion was formed that a circumferential crack had existed for some time. The end plate was cut in two, and one part was sent to the National Physical Laboratory for complete examination and test. The end of another sound drum was removed by the makers and also subjected to tests.

The exploded end plate is remarkable on account of the fracture, and because of a series or "chain" of indentations, as

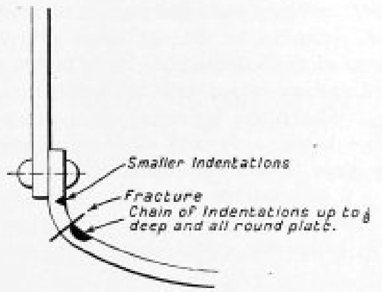


FIG. 2.—RELATION OF FRACTURE TO INDENTATIONS.

they were described, which exists all around the plate at a short distance from the knuckle; their position in section through a single indentation is indicated in Fig. 2, and they were described as being up to about 1 inch diameter by ⅛ inch deep. The adjacent indentations in many places touch each other.

At the Board of Trade examination Mr. Bowden, chief engineer to the Electricity Company, said that the boiler had been tested to 230 pounds hydraulic pressure, and put to work in August, 1906. There were never any symptoms of trouble with water hammer. When he examined the crack in the end plate it appeared to be about ¾ inch long, but later, when a microscope was brought to bear, it was found to be 2 7/16

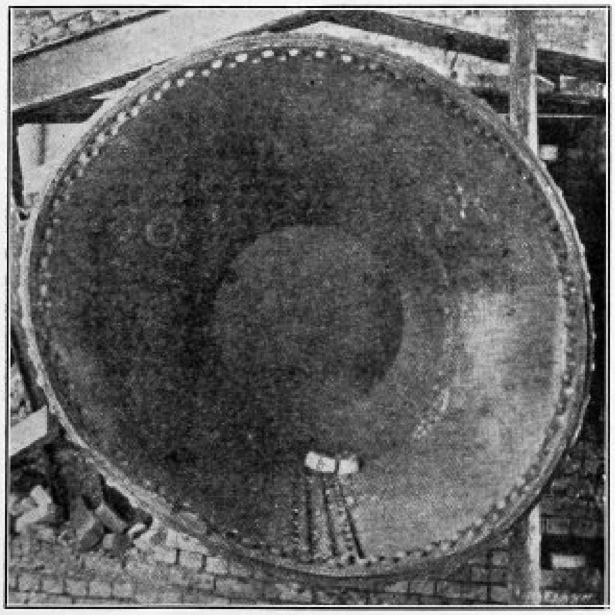


FIG. 3.—END OF TANK, SHOWING RAGGED EDGE OF FRACTURE.

inches. It was extremely fine, and was evidenced by a small leakage of steam from it. On examination on the day following the explosion he observed that about half the fracture was discolored, from which he deduced that a crack on the inside of the plate, and extending possibly half way through, had existed for some time; he could give no idea how long. There were two kinds of marks or indentations on the plate. One, occasional marks, probably made by the rivet snap, to which he attached no importance; and the other, the "chain of indentations," which he did regard as important, because he thought the metal must be distressed locally by the means producing them. The opposite drum head, which had been turned nearly inside out by impact with brick walls, showed similar marks, but he thought they were less severe. Mr. Bowden expressed the opinion that in the course of manufacture it was found that the end of the drum did not fit the barrel, and the flange was pressed or worked out cold to the required diameter.

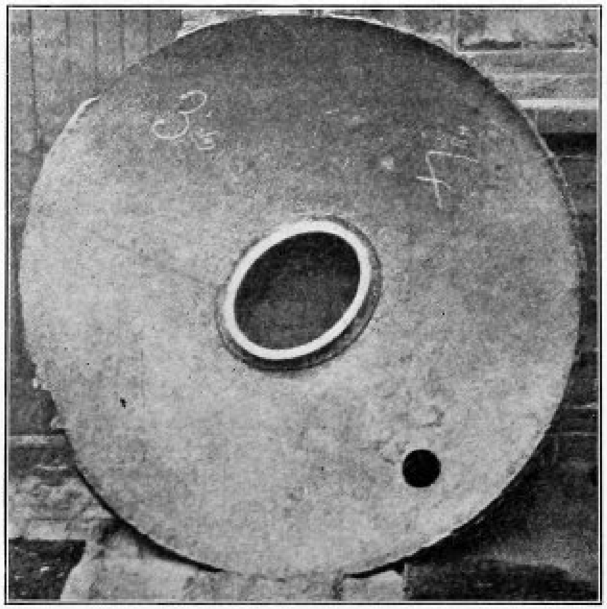


FIG. 4.—HEAD OF THE TANK WHICH WAS TORN OFF.

Mr. Kolle, assistant engineer to Babcock & Wilcox, said that out of a total of 3,695 drum ends, only .57 percent developed any defect during dishing, and practically all such defects were discovered before the ends were riveted into the drums. He judged by the appearance of the fracture that the ruptured plate was brittle. He took this view from the crystalline formation of the metal at the break, and the fact that a crack nearly five-eighths of the circumference had, as shown by discoloration, existed in the plate for some time prior to the explosion. He noticed the chain of indentations, but did not consider them of importance in connection with the explosion. The steel used for the drums was specified to have a tensile strength of between 24 and 28 tons, with a minimum elongation of 20 percent in 10 inches, and Lloyd's found actually a tensile strength of between 26.9 and 27.1 tons with an elongation of 25 percent. The tests were, therefore, eminently satisfactory. Mr. Kolle said that, in his opinion, the chain of indentations was produced in the hydraulic riveting-press by the shoulder of the snap head, and whilst they showed some crushing and distortion he did not think the damage was sufficient to affect the plates detrimentally. At the other end of the same drum he had found similar indentations which appeared to him to differ little, if at all, from those on the broken end.

Mr. Rosenthal, the managing director of Babcock & Wilcox, Ltd., suggested that the crack was due to a bubble or flaw in the original plate, which was rolled flat and closed by a thin external skin.

Mr. McLaren, the manager at Renfrew, said that the end plates were dished at one heat, and then reheated for the production of the manhole, and they were then allowed to cool slowly. The reheating for the manhole he regarded as equivalent to annealing. He did not think exception could be taken to this method, and mentioned that it was a common practice in flanged work to heat a plate locally and work upon it. The indentations, he thought, were caused by the snap, but they should not have extended beyond the cylindrical part of the dished end, but since the defect was internal he could not see how internal indentation could affect it.

Mr. Spyer, chief of the marine boiler department and assistant to the managing director of Babcock & Wilcox, Ltd., admitted that from the mechanical tests the material appeared to be quite good, and he described the appearance of the fracture when he saw it the day after the explosion; he noticed the signs of an old crack extending nearly five-eighths of the circumference, and the "chain of indentations," which puzzled him at the time. The fracture had started from the inside, and had, generally speaking, followed the chain of indentations. Such indentations should not, in a normal plate, materially affect its ductility, and if they did so in this case it would only be to a small extent. He thought that slight surface cracks which had extended with extraordinary rapidity to the outside had existed initially in the plate. These cracks were on the inner surface near the indentations, and on the dome side. He said that, whilst his view did not amount to an opinion, he had, by a process of exhausting all other probable causes, arrived at the theory that the fractured plate was made of steel, which had the peculiar property known in France as *fisselité*. Such a plate would be very liable to crack on surface injury, and through it a crack would be very readily propagated. That plates having this peculiar quality were very rare he admitted, but they undoubtedly did now and then occur. He thought it possible that cracks might be started in a plate of the kind he had in mind by such bruising as was indicated by the "chain of indentations" in the fractured plate, and in that case they would start from the inside. He did not entirely agree with Mr. Kolle about the indentations, but whilst he thought they were severe, he did not think that they should have materially injured the metal. He did not consider that they were a sign of bad workmanship, but he thought they showed that the workmanship was not of the best; the marks were perhaps a little too severe. He said that the drumhead appeared to have been hanging by a film of steel 3/32 inch thick. This he judged from an examination made on the day after the accident. It was quite impossible to estimate the actual length of the crack from the external signs.

Mr. Spyer said that he had examined other drum ends and had found them indented in the same way and practically to the same extent, but they were all apparently sound. This confirmed his view that there was some difference between the burst plate and the others. He thought it was one of those cases of mysterious fractures in steel which were much discussed by engineers. He would not expect cracks caused by the indentation of normal plates to extend, and he did not consider a surface crack in itself dangerous. The fact that Mr. Bowden, the engineer to the electricity company, had sent a message about the leak indicated to him that Mr. Bowden did not consider the crack serious or he would have shut down at once; but, in answer to the Commissioner, he admitted that if he himself saw a crack of the kind in a new boiler he would regard its as dangerous. Mr. Spyer said that he considered such drums quite safe without stays.

Mr. McLaren, the works manager at the Babcock & Wilcox works, Renfrew, said that after the accident he gave Mr. Carlton, the Board of Trade inspector, an opportunity of seeing how drumheads were constructed at the works.

Mr. Carlton reported on what he saw. In his report he describes how the plates are heated to a bright red heat in a large furnace, and then flanged in an hydraulic press at one operation. They are still bright red when they leave the press, and are stacked one above the other and shielded with iron sheets so that they may cool regularly and slowly. Those ends which have manholes like that which fractured, are reheated all over for punching and again for flanging the hole. The ends are usually driven into the barrels, but occasionally they do not fit, and the hydraulic riveting machine is used to press the surfaces together, being fitted with a blind snap for that purpose. It was the corner of this snap catching the knuckle of the flange that caused the chain of indentations.

Mr. McLaren commented on Mr. Carlton's report as follows: First, the drum ends had *always* to be driven into the barrels; and, secondly, he did not agree with the description of the making of the indentations. The report stated that the depth of indentation varied with the pressure employed; that was not so. The depth depended upon the position of the drum, relative to the snap, and since there was nothing supporting the plate behind the indentation the full load of 60 tons could not be exerted, since there was no equivalent resistance. The annexed sketch, for which accuracy is not claimed, will make the production of the "chain of indentations" clear.

The sketch Fig. 1 shows the two legs of the riveter and the blind snap attached to the inner leg. It will be observed that the upper part of the snap meets the curve of the plate at the knuckle, the result being that a small pocket is pressed locally in the plate. The thickness of the plate is little, or at all, reduced, there being no resistance to prevent bulging.

There can be little doubt as to the cause of the explosion. The drum end failed around the knuckle of the flange, because the metal had received treatment that it was unable to stand. The evidence of the experts who examined the plate was clear on the point that the chain of indentations caused an initial weakness in the plate that brought about its destruction. But the makers, on the other hand, asserted that the deformation the plate received was no greater than is daily given to mild steel, and their defense was that because the plate failed it must have been defective. The plate appears to have been of good normal quality, and the makers stated that they had flanged drum ends by the same method and to the same outline by hundreds for many years, and that they had pressed them out to make a good calking joint when circumstances required it, just as they did, or thought they did, in this case. They unwittingly exceeded the limit that the steel would bear, and disaster followed. There is no reason to think that the steel was defective, and Mr. Carlton himself has said that the general design of the drum was good, and the workmanship, apart from the chain of indentations, excellent. The accident was due to the fact that the boiler makers, unknown to themselves, stressed the metal locally beyond its limit of endurance.—Condensed from reports in *London Engineering*.

In Philadelphia there are over 10,000 boilers in daily use. The boiler inspection laws there are very severe, and boiler manufacturers want to put on a little extra price for goods intended for this market. Since the boiler explosion at Wilt & Sons' planing mill, on Front street, Philadelphia, when four men were killed (June 27, 1879), there have been but few destructive explosions of boilers in the city. At least two have occurred where loss of life occurred, and both of these were boilers of first-class construction. One occurred at the Edison Electric Light Station, and caused much litigation; the other at the Baldwin Locomotive Works, both resulting in a loss of life. These were what might be called strong and safe boilers, which would probably comply with all standard formulæ. Many explosions occur in other cities, and generally they occur in strong, well-designed but sadly neglected boilers.

Massachusetts Boiler Rules.

About a year ago the Massachusetts Legislature passed a law giving the State Boiler Inspection Department jurisdiction over the construction and inspection of all steam boilers installed in the State. In accordance with this law the Governor appointed a Board of Boiler Rules, of which Mr. Joseph McNeill, of Melrose, is chairman, to formulate a set of rules covering boiler construction and inspection. The first of these rules were approved some months ago, and covered boiler inspection (see THE BOILER MAKER, November, 1907, page 324). Since then the following rules relating to materials and construction have been formulated by the Board and approved by the Governor. These rules apply to all boilers installed after May 1, 1908.

AREAS OF SEGMENTS.

The following table of areas gives the net area in square inches of any segment of a head to be braced, as shown by diagram. This allows a 3-inch space all around the segment to be braced by the flange of the head.

Height from Tubes to Shell.	Diameter of Boiler.												
	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"
10"	57	68	77	85	93	99	106	112	117	123	129	132	137
11"	74	88	100	111	121	130	138	147	155	161	169	174	183
12"	91	109	125	139	151	163	174	184	194	203	213	219	230
13"	...	132	151	168	183	197	211	224	235	247	256	267	279
14"	...	...	178	199	217	234	250	266	280	294	305	319	331
15"	...	...	206	231	252	273	291	309	326	343	357	372	386
16"	...	...	235	263	289	312	334	355	374	394	411	423	443
17"	...	...	264	297	326	353	378	402	425	447	467	486	502
18"	...	...	...	331	365	396	424	450	476	500	520	543	564
19"	...	...	...	366	404	439	470	500	529	555	580	604	631
20"	...	...	...	401	444	483	519	552	583	613	642	667	699
21"	...	...	...	...	485	528	568	604	640	673	705	733	766
22"	...	...	...	...	526	574	618	658	697	734	769	800	835
23"	...	...	...	...	...	620	668	713	754	796	830	869	906
24"	...	...	...	...	...	667	719	768	814	859	897	939	978
25"	...	...	...	...	...	714	771	825	875	922	966	1,010	1,051
26"	...	...	...	...	...	761	824	882	936	987	1,035	1,083	1,126
27"	...	...	...	...	...	...	877	939	998	1,053	1,106	1,157	1,202
28"	...	...	...	...	...	...	930	997	1,060	1,120	1,177	1,232	1,279
29"	...	...	...	...	...	...	...	1,056	1,123	1,187	1,248	1,305	1,360
30"	...	...	...	...	...	...	...	1,115	1,187	1,255	1,321	1,382	1,442
31"	...	...	...	...	...	...	...	...	1,252	1,324	1,394	1,459	1,523
32"	...	...	...	...	...	...	...	...	1,317	1,394	1,467	1,538	1,605
33"	...	...	...	...	...	...	...	...	...	1,465	1,542	1,617	1,687
34"	...	...	...	...	...	...	...	...	...	1,536	1,617	1,695	1,770
35"	...	...	...	...	...	...	...	...	...	...	1,692	1,775	1,856
36"	...	...	...	...	...	...	...	...	...	...	...	1,857	1,941
37"	...	...	...	...	...	...	...	...	...	...	...	...	2,026

When an area is required that is not given in the table, the following formula shall be used:

$$\frac{4H^2}{3}\sqrt{\frac{2R}{H} - .608} = \text{area of segment in square inches.}$$

H = distance from tubes to shell, minus 5 inches.
R = radius of boiler, minus 3 inches.

OPEN-HEARTH BOILER PLATE AND RIVET STEEL.

Steel shall be made by the open-hearth process, and will be considered as manufactured by the basic method unless the report of tests states that the acid method has been used.

All plates and rivets used in the construction of steel shells or drums of boilers shall be as specified by the American Society for Testing Materials, adopted 1901.

CHEMICAL PROPERTIES.

There shall be three classes of open-hearth boiler plate and rivet steel, namely, flange or boiler steel, fire-box steel and extra soft steel, which shall conform to the following limits in chemical composition:

	Flange or Boiler Steel (Percent.).	Fire-Box Steel (Percent.).	Extra Soft Steel (Percent.).
Phosphorus shall not exceed	Acid, 0.06 Basic, 0.04	Acid, 0.04 Basic, 0.03	Acid, 0.04 Basic, 0.04
Sulphur shall not exceed	0.05	0.04	0.04
Manganese	0.30 to 0.60	0.30 to 0.50	0.30 to 0.50

Steel for boiler rivets shall be of the extra soft class.

PHYSICAL PROPERTIES.

The three classes of open-hearth boiler plate and rivet steel—namely, flange or boiler steel, fire-box steel and extra soft steel—shall conform to the following physical qualities:

	Flange or Boiler Steel.	Fire-Box Steel.	Extra Soft Steel.
Tensile strength, pounds per square inch	55,000 to 65,000	52,000 to 62,000	45,000 to 55,000
Yield point in pounds per square inch shall not be less than	½ T. S.	½ T. S.	½ T. S.
Elongation percent in eight inches shall not be less than	25	26	28

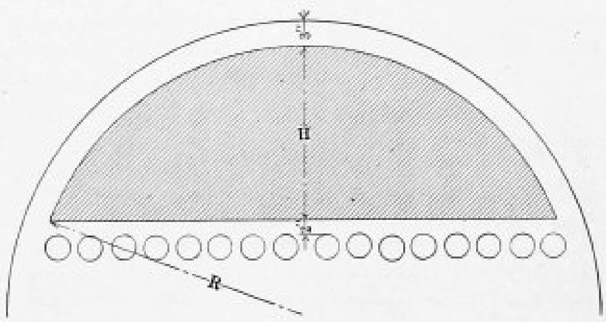


FIG. 1.—SHADED PORTION SHOWS AREA OF SEGMENT GIVEN IN TABLE.

For material less than five-sixteenths (5/16) inch and more than three-fourths (¾) inch in thickness the following modifications shall be made in the requirements for elongation:

(*a*) For each increase of one-eighth (⅛) inch in thickness above three-fourths (¾) inch a deduction of one (1) percent shall be made from the specified elongation.

(*b*) For each decrease of one-sixteenth (1/16) inch in thickness below five-sixteenths (5/16) inch a deduction of two and one-half (2½) percent shall be made from the specified elongation.

The three classes of open-hearth boiler plate and rivet steel shall conform to the following bending tests; and for this purpose the test specimen shall be one and one-half (1½) inches wide, if possible, and for all material three-fourths (¾) inch or less in thickness the test specimen shall be of the same thickness as that of the finished material from which it is cut, but for material more than three-fourths (¾) inch thick the bending test specimen may be one-half (½) inch thick.

Rivet rounds shall be tested of full size as rolled.

(*c*) Test specimens cut from the rolled material, as specified above, shall be subjected to a cold bending test, and also to a quenched bending test. The cold bending test shall be made on the material in the condition in which it is to be used, and prior to the quenched bending test the specimen shall be heated to a light cherry red, as seen in the dark, and quenched in water, the temperature of which is between 80 degrees and 90 degrees F.

(*d*) Flange or boiler steel, fire-box steel and rivet steel, both before and after quenching, shall bend cold one hundred and eighty (180) degrees flat on itself without fracture on the outside of the bent portion.

For fire-box steel, a sample taken from a broken tensile test specimen shall not show any single seam or cavity more than one-fourth (¼) inch long in either of the three fractures obtained on the test for homogeneity.

TEST PIECES AND METHODS OF TESTING.

The standard test specimen of eight (8) inch gaged length shall be used to determine the physical properties. The standard shape of the test specimen for sheared plates shall be as shown in the following diagram.

For other material the test specimen may be the same as for sheared plates, or it may be planed or turned parallel throughout its entire length; and in all cases, where possible two opposite sides of the test specimens shall be the rolled surfaces. Rivet rounds and small rolled bars shall be tested of full size as rolled.

One tensile test specimen will be furnished from each plate as it is rolled, and two tensile test specimens will be furnished from each melt of rivet rounds. In case any of these develops flaws or breaks outside of the middle third of its gaged length, it may be discarded and another test specimen substituted therefor.

For material three-fourths (¾) inch or less in thickness the bending test specimen shall have the natural rolled surface on two opposite sides. The bending test specimens cut from plates shall be one and one-half (1½) inches wide, and for

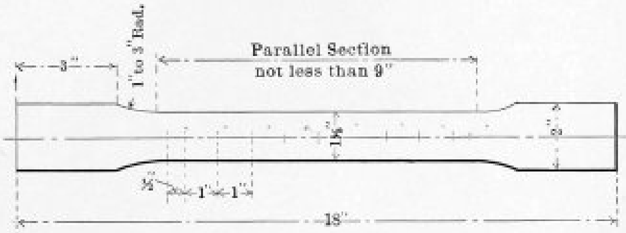


FIG. 2.—STANDARD TEST PIECE.

material more than three-fourths (¾) inch thick the bending test specimen may be one-half (½) inch thick. The sheared edges of bending test specimens may be milled or planed. The bending test specimens for rivet rounds shall be of full size as rolled. The bending tests may be made by pressure or by blows.

One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. Two cold bending specimens and two quenched bending specimens will be furnished from each melt of rivet rounds. The homogeneity test for fire-box steel shall be made on one of the broken tensile test specimens.

The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about a sixteenth (1/16) of an inch deep, in three places about two (2) inches apart. The first groove should be made on one side two (2) inches from the square end of the specimen; the second, two (2) inches from it on the opposite side; the third, two (2) inches from the last, and on the opposite side from it. The test specimen is then put in a vise, with the first groove about one-fourth (¼) of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used, if necessary, and the length of the seams and cavities is determined.

For the purposes of this specification the yield point shall be determined by the careful observation of the drop of the beam or halt in the gage of the testing machine.

In order to determine if the material conforms to the chemical limitations prescribed in this section, analysis shall be made of drillings taken from a small test ingot. An additional check analysis may be made from a tensile specimen of each melt used on an order, other than in locomotive fire-box steel. In the case of locomotive fire-box steel a check analysis may be made from the tensile specimen from each plate as rolled.

VARIATION IN WEIGHT.

A variation in cross-section of weight of more than 2½ percent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

(*e*) Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ percent variation above or 2½ percent below the theoretical weight; when 100 inches wide and over, 5 percent above or 5 percent below the theoretical weight.

(*f*) Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following: Up to 75 inches wide, 2½ percent below the theoretical weight; 75 inches wide up to 100 inches wide, 5 percent below the theoretical weight; when 100 inches wide and over, 10 percent above or 3 percent below the theoretical weight.

(*g*) For all plates ordered to gage there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

TABLE OF ALLOWANCES FOR OVERWEIGHT FOR RECTANGULAR PLATES WHEN ORDERED TO GAGE.

[Plates will be conidered up to gage if measuring not over 1-100 inch less than the ordered gage. The weight of 1 cubic inch of rolled steel is assumed to be .2833 pound.]

PLATES ¼ INCH AND OVER IN THICKNESS.

Thickness of Plate. (Inch).	Width of Plate.		
	Up to 75 Inches (Percent.).	75 to 100 Inches (Percent.).	Over 100 Inches (Percent.).
¼	10	14	18
5/16	8	12	16
⅜	7	10	13
7/16	6	8	10
½	5	7	9
9/16	4½	6½	8½
⅝	4	6	8
Over ⅝	3½	5	6½

PLATES UNDER ¼ INCH IN THICKNESS.

Thickness of Plate (Inch).	Width of Plate.	
	Up to 50 Inches (Percent.).	50 Inches and Above (Percent.).
⅛ up to 5/32	10	15
5/32 up to 3/16	8½	12½
3/16 up to ¼	7	10

FINISH.

All finished material shall be free from injurious surface defects and laminations, and must have a workmanlike finish.

PLATE MANUFACTURER TO STAMP PLATES AND HEADS.

Each plate shall be distinctly stamped by the manufacturer with the heat number, and in at least five places in the following manner: At the four corners, at a distance of about twelve (12) inches from the edges, and at or near the center of the plate, with the name of the manufacturer, place where manufactured, brand and lowest tensile strength.

Each head shall be distinctly stamped by the manufacturer on each side with the name of the manufacturer, place where manufactured, brand and lowest tensile strength; stamps to be so located as to be plainly visible when the head is finished.

MATERIAL TO BE USED IN SHELLS AND DRUMS.

Shells, drums and butt straps shall be of open-hearth fire-box steel.

Heads, combustion chambers, furnaces, or any plates that require staying or flanging, shall be of open-hearth flange, fire-box or extra soft steel.

Rivets shall be of open-hearth extra soft steel.

Cast steel for use in boiler and steam superheater mountings, manhole frames, steam pipe, fittings, side lugs, or any other parts of boilers or superheaters where cast steel is used, shall not have less than sixty thousand (60,000) pounds tensile strength.

Cast iron for use in boiler mountings, steam pipe fittings, side lugs, or any other parts of boilers where cast iron is permitted to be used, shall not have less than eighteen thousand (18,000) pounds tensile strength.

DETAILS OF CONSTRUCTION AND INSTALLATION.

In laying out plates and heads in the boiler shop care must be taken to leave at least one of the stamps so located as to be plainly visible when the boiler is completed.

Each boiler shall conform in every detail with the rules formulated by this board, and shall be distinctly stamped by the builder with the words, "Massachusetts Standard," abbreviated to read MASS. STD., also with a serial number and with the name of the builder, either in full or abbreviated; and the builder shall submit a fac-simile of his proposed style of stamping to this board for approval. The height of letters and figures used in stamping shall not be less than one-fourth (¼) inch.

In numbering serially each builder shall commence with the number one (1) and continue numbering in consecutive order.

A data report, on forms to be furnished by the boiler inspection department of the district police, shall be forwarded by the builder to said department, for each boiler stamped by said builder as above specified.

Location of stamps to be as follows:

(*a*) On horizontal return tubular boilers—on the front head above the central rows of tubes.

(*b*) On horizontal flue boilers—on the front head above the flues.

(*c*) On locomotive type or Star water-tube boilers—on the furnace end above the handhole.

(*d*) On vertical fire and vertical submerged tube boilers—on the shell above the furnace door.

(*e*) On water-tube boilers, Babcock & Wilcox, Stirling, Heine and Robb-Mumford standard types—on a head above the manhole opening, preferably on the flanging of the manhole opening.

(*f*) On vertical boilers, Climax or Hazelton type—on the top head.

(*g*) On Cahall vertical water-tube boilers—on the upper drum above the manhole opening.

(*h*) On Scotch marine boilers—on the front head above the center or right-hand furnace.

(*i*) On Economic boilers—on the rear head above the central rows of tubes.

(*j*) For other types and new designs—in a location to be approved by this board.

The boiler builder's stamp shall not be covered by insulating or other material.

The maximum pressure allowed on a shell or drum of a boiler shall be based on a factor of safety of not less than five (5).

The longitudinal joints of a boiler, the shell or drum of which exceeds thirty-six (36) inches in diameter, shall be of butt and double strap construction.

The longtudinal joints of a boiler, the shell or drum of which does not exceed thirty-six (36) inches in diameter, may be of lap-riveted construction; and the maximum pressure allowed on such shells or drums shall not exceed one hundred (100) pounds per square inch.

Any form of longitudinal joint other than specified above shall be submitted to this board for approval.

The longitudinal joints of horizontal return tubular boilers shall be located above the fire line of the setting.

A horizontal return tubular, vertical tubular or locomotive type boiler shall not have a continuous longitudinal joint over twelve (12) feet in length.

The thickness of plates in a shell or drum shall be of the same gage.

The minimum thickness of plates used in the construction of a boiler shall be one-fourth (¼) inch.

The minimum thickness of shell plate shall be as follows:

When the Diameter of Shell is—			
36" or Under.	Over 36" to 54" Inclusive.	Over 54" to 72" Inclusive.	Over 72".
Not less than 1/4"	Not less than 5/16"	Not less than 3/8"	Not less than 1/2"

Butt straps shall be rolled to the proper curvature on forms made for that purpose.

The thickness of butt straps shall be in proper proportion to the thickness of the shell plates, and in no case shall they be less than five-sixteenths (5/16) inch in thickness.

The minimum thickness of heads and tube sheets of horizontal return tubular and vertical fire-tube boilers shall be as follows:

When the Diameter of Boiler is—				
42" or Under.	Over 42" to 54" Inclusive.	Over 54" to 72" Inclusive.	Over 72" to 78" Inclusive.	Over 78" to 84" Inclusive.
3/8".	7/16".	1/2".	9/16".	5/8".

In no case shall the thickness of heads and tube sheets of horizontal return tubular and vertical fire-tube boilers be less than the thickness of the shell plates.

The thickness of plate in stayed flat surface construction shall not be less than five-sixteenths (5/16) inch.

Rivet holes shall be drilled full size in place or punched at least one-fourth (¼) inch less than full size. When the holes are punched they shall then be drilled to full size, with plates, butt straps and heads bolted up in position, after which the plates shall be separated and all burrs removed.

Rivets shall be of sufficient length to completely fill the rivet holes and form a head equal in strength to the body of the rivet.

Rivets shall be machine driven, wherever possible, with sufficient pressure to fill the rivet holes, and shall be allowed to cool and shrink under pressure.

The shearing strength of steel rivets shall be as specified in these rules.

Tube holes shall be drilled full size, or the center punched out not to exceed one (1) inch in diameter and finished up full size with a rotating cutter.

The edges of tube holes shall be chamfered to a radius of about one-sixteenth (1/16) inch.

The calking edges of plates and heads shall be beveled wherever possible. Calking shall be done with a round-nosed tool.

Openings in shells, drums or heads, for pipe connections over one and one-quarter (1¼) inches in diameter, except feed-pipe connections where a brass bushing or its equivalent shall be used, shall be re-enforced with a standard commercial pressed steel flange, or with a steel plate, the thickness of which shall not be less than the thickness of the shell plate. Main steam and safety valve openings may be fitted with cast steel or cast iron nozzles.

The standard manhole opening shall be an ellipse eleven by fifteen (11 by 15) inches.

There shall be a standard sized manhole in the upper part of the shell or head of a fire-tube boiler over thirty-six (36) inches in diameter, except vertical fire-tube boilers.

A manhole frame shall be of wrought or cast steel, and have a net cross-sectional area, on a line parallel to the axis of the shell, not less than the cross-sectional area of shell plate removed on the same line.

The strength of manhole plates, yokes and bolts shall be in proportion to the strength of the manhole frames.

Manhole plates shall be of wrought or cast steel.

Manhole frames on shells or drums shall have the proper curvature, and on boilers over forty-eight (48) inches in diameter shall be double-riveted to the shell or drum.

The standard handhole shall be an ellipse of the following sizes:

Two and one-fourth by three and one-fourth (2¼ by 3¼) inches.

Three by four and one-half (3 by 4½) inches.

Four by six (4 by 6) inches.

A standard sized manhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler sixty (60) inches or over in diameter.

A standard sized manhole or handhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler less than sixty (60) inches in diameter.

A standard sized handhole shall be located in the rear head, of a horizontal return tubular boiler, except one which has a standard sized manhole in the front head, below the tubes.

A locomotive type boiler shall not have less than six (6) standard sized handholes, located as follows:

One in the rear head below the tubes.

One in the front head at or about the line of the crown sheet.

Four in the lower part of the water leg.

A vertical fire-tube boiler, except the boiler of a steam fire engine, shall have not less than three (3) standard sized handholes, located as follows:

One in the shell at or about the line of the crown sheet.

Two in the shell at the lower part of the water leg.

A vertical fire-tube boiler of a steam fire engine shall not have less than three (3) brass washout plugs of not less than one (1) inch pipe size, screwed into the shell and located as follows:

One at or about the line of the crown sheet.

Two at the lower part of the water leg.

There shall not be less than one and one-half (1½) inches of solid plate around a handhole opening in a shell or drum of a boiler.

The maximum size of a surface blow-off pipe shall not exceed one and one-half (1½) inches, and it shall be carried through the shell or head with a brass boiler bushing.

A bottom blow-off pipe shall be fitted with a valve or cock; the minimum size of pipe and fittings shall be one (1) inch and the maximum size shall not exceed two and one-half (2½) inches. Globe valves shall not be used.

When the pressure allowed on a boiler exceeds twenty-five (25) pounds per square inch the bottom blow-off pipe and fittings, from the boiler to the valve or valves, shall be extra heavy.

When the pressure allowed on a boiler exceeds one hundred and thirty-five (135) pounds per square inch the bottom blow-off pipe shall have two (2) valves, or a valve and a cock; and such valves, or valve and cock, shall be extra heavy.

When a bottom blow-off pipe is exposed to the products of combustion it shall be protected by a substantial cast-iron removable sleeve or equivalent covering of non-conducting material.

An opening in brickwork for a blow-off pipe shall be fitted with an ample cast or wrought iron sleeve, to provide for free expansion and contraction.

A bottom blow-off cock shall have the plug held in place by a guard or gland. The end of the plug shall be distinctly marked in line with its passage, and a handle shall be securely attached to the plug in line with the mark on the end of the plug.

All stop valves two (2) inches and over in diameter shall be of the outside screw and yoke type.

When boilers, on which the allowable pressure exceeds one hundred and thirty-five (135) pounds, are set in battery, the main steam pipe shall have two (2) stop valves of the outside screw and yoke type, with an ample valved drain between them having an open discharge. The pipe and fittings, up to and including the valves, shall be extra heavy, made to the manufacturers' standard for high pressure.

The feed pipe of a boiler shall be of brass from the check valve to the discharge end, and shall have open end or ends.

When boilers of fifty (50) H. P. or over are set in battery each boiler shall have two (2) stop valves, or a stop valve and stop cock, on the feed pipe, one on each side of the check valve.

The feed water shall discharge about three-fifths (3/5) the length of a horizontal return tubular boiler from the front head, and at or about the central rows of tubes above the upper row, when the diameter of the boiler exceeds thirty-six (36) inches and the pressure allowed exceeds twenty-five (25) pounds per square inch. The feed pipe shall be carried through the head or shell with a brass boiler bushing, and securely fastened inside the shell above the tubes.

When a boiler of over fifty (50) H. P. has a pump, inspirator or injector as the primary means of supplying feed water when the maximum pressure allowed is carried, more than one such mechanical appliance shall be provided.

The temperature of the usual feed water entering a boiler shall not be less than 120 degrees F. when the pressure allowed exceeds twenty-five (25) pounds per square inch.

Feed water shall not discharge in a boiler in close proximity to riveted joints in shell or furnace sheets.

The minimum size of pipes connecting the water column of a boiler shall be one (1) inch.

No connections, except for damper regulator, drains or steam gages, shall be placed on the pipes connecting the water column to the boiler.

When shut-off valves are placed on the pipes connecting a water column to a boiler, these valves shall be of the straight-way outside screw and yoke type, and shall be locked or sealed *open*.

No water-glass shall have automatic shut-off valves.

The water connection to the water column of a boiler shall be of brass when the allowable pressure exceeds twenty-five (25) pounds per square inch.

The steam connection to the water column of a horizontal return tubular boiler shall be taken from the top of shell or the upper part of head; the water connection shall be taken from a point not less than six (6) inches below the center line of the shell.

A horizontal return tubular boiler over seventy-eight (78) inches in diameter shall be supported from steel lugs by the outside suspended type of setting; where three supports are necessary on each side of a boiler an equalizer shall be used.

A horizontal return tubular boiler over fifty-four (54) inches in diameter, and up to and including seventy-eight (78) inches in diameter, shall be supported by the outside suspended type of setting, or by not less than four (4) steel or cast-iron brackets on each side, set in pairs.

A horizontal return tubular boiler up to and including fifty-four (54) inches in diameter shall be supported by the outside suspended type of setting, or by not less than two (2) steel or cast-iron brackets on each side.

Supporting lugs or brackets shall have the proper curvature and be securely riveted to the shell.

When it is necessary to place a fusible plug in a tube an extra thick tube shall be provided for that purpose.

Water-leg and door-frame rings of internally fired boilers thirty-six (36) inches or over in diameter, shall be of wrought iron or wrought steel.

The upper surface of the fire-grate of an internally fired boiler of the open-bottom locomotive, vertical fire tube or similar type shall not be less than two (2) inches above the row of rivets at the lower end of the furnace.

Wet bottom boilers shall have a clear space of not less than twelve (12) inches between the bottom of the boiler and the floor line.

A fire-tube boiler shall have the ends of the tubes substantially beaded.

The ends of all tubes, suspension tubes and nipples shall be flared not less than one-eighth (1/8) inch over the diameter of the tube hole on all water-tube boilers and superheaters.

The ends of all tubes, suspension tubes and nipples of water-tube boilers and superheaters shall not project through the tube sheets or headers less than one-fourth (1/4) inch nor more than one-half (1/2) inch. Separately fired superheaters shall have the tube ends protected by refractory material where they connect with drums or headers.

Cross pipes connecting the steam and water drums of water-tube boilers and cross boxes shall be of wrought or cast steel when the working pressure exceeds one hundred and sixty (160) pounds per square inch.

Provision shall be made for the expansion and contraction of steam mains connected to all boilers, with substantial anchorage at suitable points, that there may be no perceptible vibration on the boiler shell plates.

Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration on the boiler shell plates.

When boilers have their safety valves set at different pressures, and are connected to a common steam main, the boilers allowed the lowest pressure shall each be protected by a safety valve or valves placed on the connecting pipe to the steam main. The area or combined area of the safety valves shall not be less than the area of the connecting pipe.

Pressure parts of superheaters, attached to boilers or separately fired, shall be of wrought or cast steel when the working pressure exceeds fifty (50) pounds per square inch.

Boiler and superheater mountings, such as nozzles, cross pipes, steam pipes, fittings, valves and their bonnets shall be of wrought or cast steel when exposed to steam which is superheated over 80 degrees F.

When a superheater can be shut off from a boiler, whether attached or separately fired, it shall have an ample safety valve at or near the steam inlet.

All boilers set in battery and superheating the steam they generate over 80 degrees F. shall have two (2) stop valves, with an ample valved drain between them having an open discharge.

All superheaters shall be fitted with drains from headers or drums where water of condensation can collect.

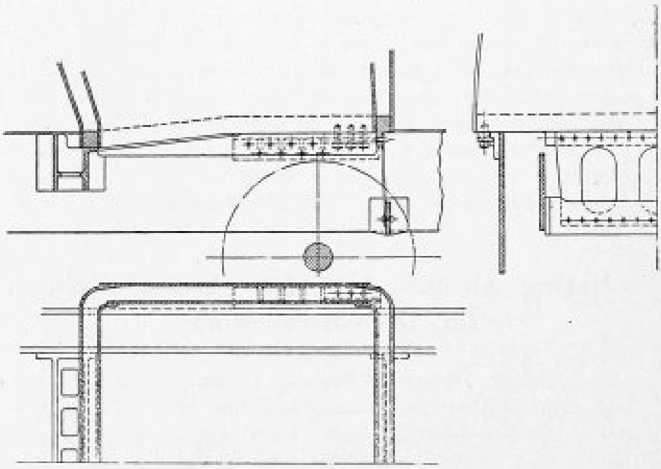
All boiler shops in which boilers are constructed for installation in this Commonwealth shall be open to the members of the boiler inspection department of the district police and inspectors holding certificates of competency as inspectors of steam boilers, at all reasonable hours, for inspection of material, methods of manufacture, workmanship and testing.

This board does not recommend the use of externally-fired boilers over eighty-four (84) inches in diameter.

(Further rules governing new construction will be issued later.)

Supports for Wide Fireboxes.

The Great Northern Railroad, of England, uses the following method of supporting the fire-boxes in their large Atlantic engines with wide fire-boxes. It will be at once apparent that the usual style of expansion bracket cannot be used, as the fire-box is wider than the distance between the frames. A cast steel angle bracket is attached to the outside frames, and on this the rear part of the foundation ring rests for about half its length; about one-third in length and width of the



PLAN, SIDE AND END VIEWS OF THE SUPPORT.

top flange of the bracket is cut away in order to make room for a clip, which is checked out to receive the reduced web of the angle, and is secured to the foundation ring by 1¼-inch studs. The front of foundation ring rests for the greater part of its length on a steel casting extending between the inside of the frames. The boiler is further held down by a thin plate, the top edge of which is riveted to a projection on the bottom of the back portion of the foundation ring; the lower edge of this plate is riveted to a frame cross-stay, and the flexibility of the plate permits of the boiler expanding without hindrance.

New Method of Welding Tubes.

Consul Albert Halstead reports that two Americans who have been employed in a tube factory in the vicinity of Birmingham have patented an improved method for the manufacture of welded iron and steel tubes, applicable to both butt and lap welding, concerning which he says:

It is claimed that the patent, which is already in successful use in this district, not only assures a more perfect weld, but permits of great economy in the making of tubes. The process consists of blowing cold air, or air and gas, upon the edges of the steel or iron strip which is to be welded. In practice the air blast alone is used, because it is regarded as better; but a combination of air and gas can also be employed. The effect of the air blast upon the iron or steel bar, which is drawn through the furnace at what is regarded as welding heat, is similar to that of blowers on coal or wood—it more than doubles the temperature of the edges.

The device consists of cast-iron arms placed on each side of the furnace. Each arm has a slot hole 18 inches in length and 3/16 of an inch in width, and by means of a rest the strip is held right in front of the slots. Through the slot holes cold air is blown by the use of ordinary rotary blowers on each edge of the strip. The air blast, while heating the edge of the strip to a greater temperature, through the mixture of the oxygen in the air with the impurities in the steel and iron, leaves a perfect edge. In butt welding the tube is drawn through the usual bell, its edges being squeezed together, and an even butt-welded joint results. The process can also be applied to the well-known method of manufacturing butt-welded iron and steel tubes by squeezing the edges of the heated strip or skelp together with tongs as it is drawn from the furnace.

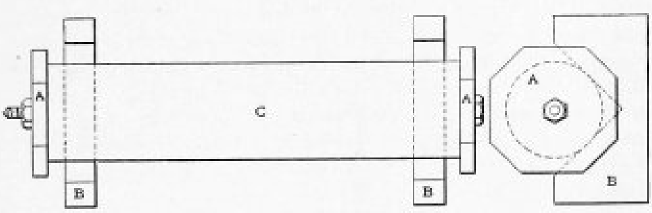
In lap welding, the air is driven so as to impinge on the scarfed edges of the strip or skelp as it leaves the furnace, and just before it passes through the welding rolls, so that the scarfed edges are raised to the proper welding heat, and a perfect and proper lap weld is formed.

It is claimed for this invention that it absolutely obviates the loss that sometimes occurs when the strip buckles, because too hot, or is burned by the excessive heat. An improper weld is formed, or the tube becomes elongated and distorted in the process of drawing and welding. This is because, while the whole strip is necessarily of a very high temperature when drawn from the furnace, its edges only are superheated by the air blast.—*Consular Report.*

Making Air-Hoist Cylinders—Liquid Chalk for Sheet-Metal Work.

I received an order to build several air hoists to be used in a large railroad shop, and was told to use what I could find around the shop to build them. I found some old 8, 10 and 12-inch pipe. After cutting the pipe to the desired length, 6 feet, I was "up against" it to bore them out, not having a machine that I could use without going to a big expense to rig up special tools, so I tried the following way:

I cut two hardwood blocks *A* 12 inches square by 1½ inches thick, and bored a 1-inch hole in the center of each. I then



RIGGING FOR BORING THE PIPE.

got two old blocks *B* about 4 feet long and 10 by 10 inches, sawed a V in the center of each block and greased the V.

I filled the pipe *C* about half full of small pieces of scrap and sand and clamped the blocks *A* over each end by putting a rod through the center with a nut on each end.

I laid the pipe in the V-blocks and ran a belt around the pipe and over the line shaft so that the pipe made about 30 revolutions a minute. Allowing the pipe to revolve 10 hours, I examined the inside and found that all the high spots were worn down, and that it was just as smooth and bright as if it had been machined. These hoists gave good service, and the packing leather will last a long time if kept soft by oiling.

To lay out work, mix whiting and water until it is about as thick as paint. Add sal ammoniac, one to four parts of water; this solution will not rust polished surfaces. After it dries thoroughly it will not scale off, and so is invaluable to sheet metal workers. It can be applied with an old paint brush. If left standing in an open pail, the water soon evaporates and the whiting forms in a solid cake in the bottom of the pail; however, by adding water to it, it is just as good as when first mixed.—H. I. Burrhus, in *American Machinist.*

A Pneumatic Dolly Bar.

The small pneumatic dolly illustrated herewith, is used for "holding on" while riveting ball joint rings on the ends of locomotive dry pipes. This is not an entirely new device, but there are, doubtless, a number of shops not provided with this useful tool. The dolly is shown in detail in Fig. 1. It consists of a cylinder *A*, into which the leather-packed plunger *B* is fitted. A head *C*, which is cupped to fit the head of the rivet,

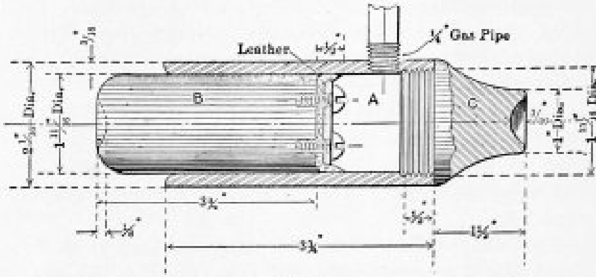


FIG. 1.

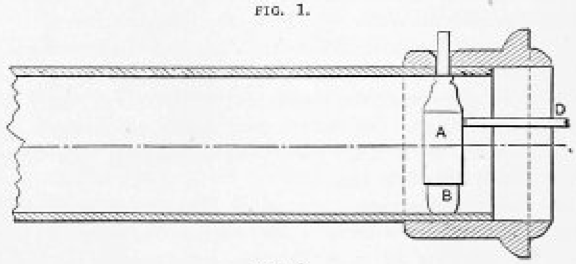


FIG. 2.

is held against it, as illustrated in Fig. 2, and the compressed air is admitted to the cylinder *A* by the pipe *D*. The air forces the plunger *B* against either the wall of the pipe or the head of a rivet opposite, holding the rivet to be hammered securely in place.—M. H. Westbrook in *Machinery.*

A Clyde Shipbuilder on Pneumatic Tools.

Mr. John Ward, a partner of Messrs. William Denny & Brothers, Leven Shipyard, Dumbarton, and president of the Scottish Institution of Engineers and Shipbuilders, spoke recently on the labor problems of the shipbuilding industry at a social gathering in that town. He said that in the open market for new ships the most dreadful competition that had ever been seen had taken place within the last year or eighteen months, and was going on at the present moment. Shipbuilders openly acknowledged that, so far from profit being an object, it had disappeared into the background, and that now they looked upon it as a necessity to keep their places going at any cost. And while this was so at home, Germany and America were rapidly pulling up on them, and had produced some fine work during the past year. In the latter country, which we had visited, pneumatic tools for calking, cutting and riveting were in general use, and the results of their adoption were the lessening of the heavy manual labor and substantial increases of the workmen's earnings, together with improved workmanship. On this side of the Atlantic they had had experience of the calking and cutting tools; but, from some inexplicable reason, a dead-set had been made against them by the men for riveting. He was certain were they given an honest trial there would be a great advantage.

The Layout of a Taper Course.

BY CLARENCE REYNOLDS.

The first thing in this layout is to find the neutral diameter at each end of Fig. 1. This course is 70½ inches outside diameter at the big end, 54 inches inside diameter at the little end, 48 inches between the flange lines and 23/32 inch thick. The neutral diameter of the big end therefore equals 70½ inches — 23/32 inch, or 69 25/32 inches. The neutral diameter of the little end equals 54 inches + 23/32 inch, or 54 23/32 inches. Now draw two circles as shown in Fig. 2, one 69 25/32 inches diameter and the other 54 23/32 inches diameter; setting your trammel points at 34 57/64 inches for the radius of the large circle and at 27 23/64 inches for the radius of the small circle.

Divide one-half of the circle representing the big end of the course into any convenient number of spaces as shown in Fig. 2. In like manner divide the inner circle, which represents the small end, into the same number of spaces as shown. These points are called the points of intersection. Draw a solid line from the large circle to the corresponding point on the small circle as indicated by the letters *A, B, A', B'*; also connect the points on the inner circle with the next letter on the outer circle as indicated by the dotted lines. Thus connect *A'* with *B* and so on, as shown. These lines just drawn are the bases of a number of right-angle triangles whose altitudes are equal to the distance between the flange lines *A A* and *B B* in Fig. 1, and whose hypothenuses, when drawn, will give the correct distances across the pattern, or the envelope of the article, between the points in the big end and those in the small end in the direction indicated in Fig. 2.

The triangles having solid lines are shown in Fig. 4, while those having the dotted lines are shown in Fig. 5. At any convenient point erect a perpendicular *A B*, Fig. 4, whose length is equal to the distance between the flange lines Fig. 1, which is 48 inches. On the base line *C D*, measuring from *A'* set off the lengths equal to the solid lines in Fig. 2, as at 1, 3, 5, 7, 9, etc. From the points thus established on the base line, draw lines to the point *B'*. The triangles thus constructed will represent sections through the article on the solid lines in Fig. 2. In like manner construct the triangles shown in Fig. 5, using the dotted lines instead of the solid lines.

In developing the pattern draw a solid line as shown at *E E'*, Fig. 6, equal in length to the distance between the flange lines in Fig. 1. Then take two pairs of dividers and set one to the length of the spaces on the big circle and the other to the length of the spaces on the little circle Fig. 2. Using *E'* as a center, Fig. 6, and the dividers just set to the small spaces, strike an arc toward *F'*. Then taking the distance *B*-16 of Fig. 5, with the trammel points, and with *E* as a center, in Fig. 6, intersect the small arc just made at *F'*. Now, using *E* as a center, and the dividers set to the large spaces, strike an arc toward *F*. Then using *F'* as a center and *B'*-15 as a radius, Fig. 4, cut the small arc at *F*, and so on until the whole pattern is complete.

After the article, as shown in Figs. 2 and 3 is complete, Fig. 3 being the elevation of the article, add to this pattern the amount of flange called for, which is 5 inches at the small end and 5 7/16 inches at the large end. Then draw the rivet lines as called for. After having the rivet lines and the amount of flange added, space the number of holes wanted on the lines of intersection *G G'*. Then using *J* as a center and *J H* as a radius, strike an arc cutting the outside rivet line at *H*. Do this until all the holes in the outside rivet line are placed. Then using *L* as a center, and *L K* as a radius, strike

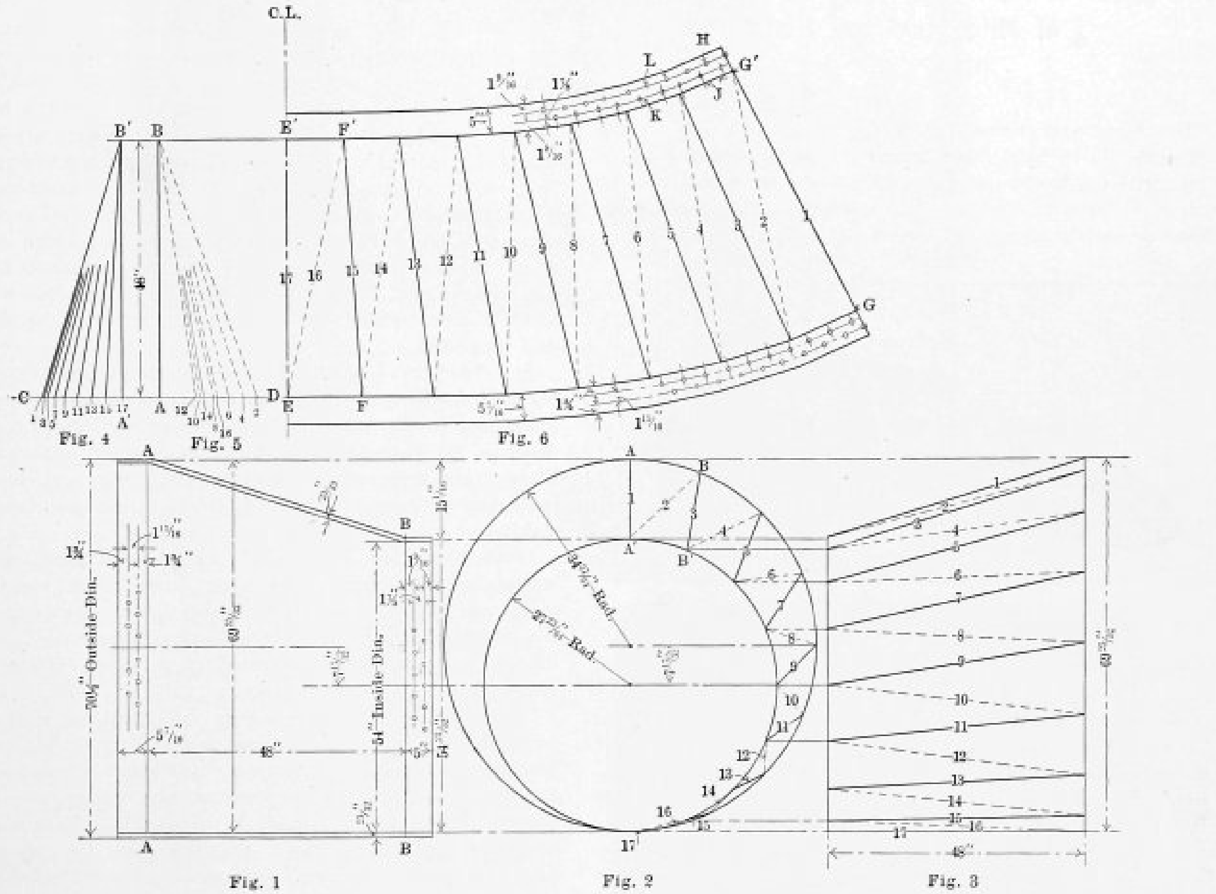


Fig. 1 Fig. 2 Fig. 3

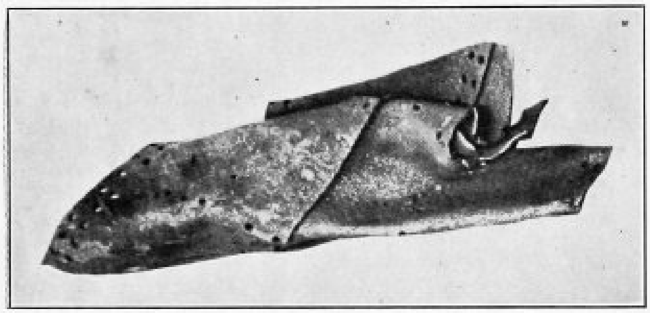
SIDE AND END VIEWS OF THE COURSE, WITH DETAILS OF TRIANGULATION AND DEVELOPMENT OF PATTERN.

an arc cutting the inside rivet line at *K*. This completes Fig. 6. The reason I have taken all these measurements is to show the reader how to allow for the thickness of material, or, in other words, how to lay out a taper course for a boiler and make it fit. If this method is carried out properly, every hole will be exactly in its right place and it will be exact in circumference and fit the shell of the boiler to perfection. A great many people, in putting holes in a taper course, find that when it is fitted up the holes are very bad, but with this method it is not so. You can put a 1¼-inch bolt in a 1 9/32-inch hole.

The Effect of Work and Time on the Properties of Mild Steel and Iron.*

BY JOHN H. HECK.

It is now over twenty years ago since mild steel, on the Siemens Martin acid open-hearth system, was first made in this district. At the present time it has quite ousted iron for use in all kinds of constructional work, and experience shows that for such purposes mild steel is the most useful and reliable material that we have to stand hard and continuous work.



DAMAGED SHIP PLATE FROM S. S. "ROTTERDAM."

One of the reasons for its rapid growth and use is no doubt due to the fact that its quality has always been kept good, either for ship or machinery purposes, by the care which has been taken during its manufacture and by the prompt and rigid testing of the material directly after its production at the steel works. Steel-makers have always been willing to make tests, and much credit is due to them, even from the early times, for the wise and far-seeing policy which they urged, as time went on, that the character and the testing of the material should not in any way be reduced or made less stringent.

* Read before the Northeast Coast Institute of Engineers and Shipbuilders, at Newcastle-upon-Tyne, England, Nov. 29, 1907.

At first, as many of the older members of this institution will remember, there was a good deal of natural hesitation about using a material about which, so far as the effect of time and work was concerned, we had so little knowledge and experience. It was the consistent and continued production of good steel which gradually inspired confidence and therefore helped on the general adoption of mild steel for all classes of constructional work.

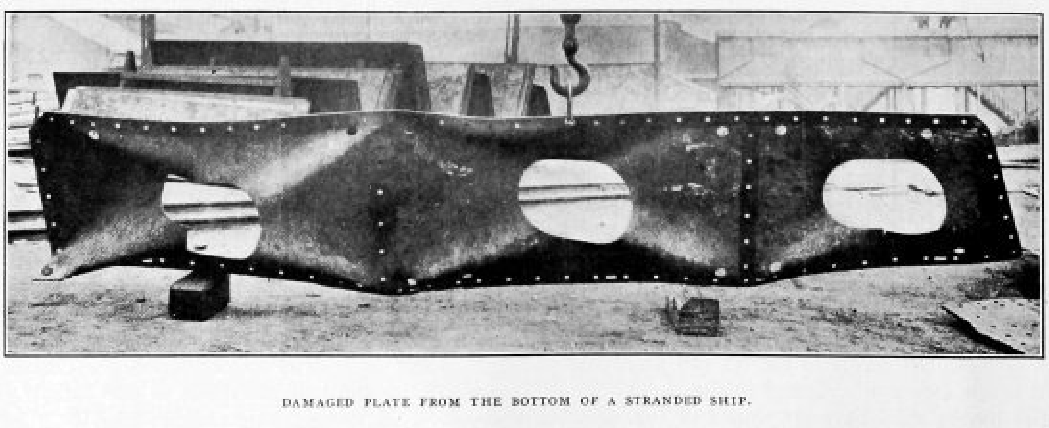
The uniform and regular testing to which it was subjected gave a "hall mark" to steel over all other metals, as a material which had been proved and could be relied on. The testing was fair all round, and was at least one of the main factors which caused the use and production of steel to grow year after year to greater dimensions.

When iron was chiefly employed in the construction and repairing of ships and boilers, the quality of the material was always a question entailing anxiety and consideration; while at the present time, with steel, vessel after vessel is built or repaired without the slightest question or anxiety arising. It is a very rare occurrence for a steel plate or angle to fail in the shipyard or boiler works. It is quite as easy to make bad steel as to make bad iron; it is also as easy to burn steel as to burn iron. It therefore speaks volumes for the care which must be taken in the manufacture of steel when a comparison is made between the great quantity of good material supplied with the small quantity which fails during construction in the shipyard or boiler shop.

The Northeast Coast of England is one of the largest shipbuilding districts, and so far as the repair of vessels and their machinery is concerned, it is also one of the largest repairing districts. It is, therefore, a daily and common experience for those engaged in such work to see on a large scale how well mild steel will stand the test of time, severe damage and wear and tear.

In the dry docks, steel vessels, owing to damage caused by stranding, collision or other causes, come under repair with plates and angles much indented and distorted, in some cases the damaged material, although not cracked or fractured, having the appearance presented by a sheet of note paper when crumpled up in the hand.

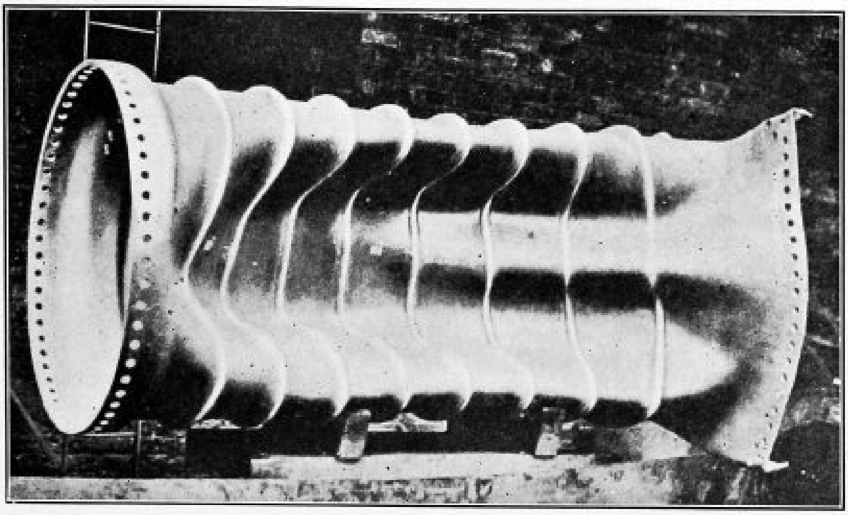
In connection with steel boilers also, working with a high pressure of steam, cases are met with where, owing to overheating and other causes, furnaces and plates are found much distorted and strained, without any serious consequences having ensued. To see steel vessels and boilers which have sustained such damage brought safely into dry dock for repairs is a fact which speaks for itself and compels one to feel there can be no deterioration, or else it can only be of a trifling extent, in the quality of a material which will stand such a test after years of work in all parts of the world and in all kinds of weather, and this conclusion is confirmed if samples are



DAMAGED PLATE FROM THE BOTTOM OF A STRANDED SHIP.

sheared off from such damaged material and thoroughly tested.

In the early days of steel making in this district I was engaged in testing the material which was used in the construction of vessels and machinery intended for classification in Lloyd's Register. Since then tests have been made from time to time on samples of old steel which had been in use and at work for a number of years in different parts of the hull and machinery of steam vessels. The samples tested were sheared from plates, angles, bars, etc., which had been removed owing to damage, corrosion, pitting, wear and tear and other causes. The tables at the end of the paper show some of the results of the tests. The number given for the purpose of illustration was deemed sufficient.



LENGTH OF BULGE IN OVERHEATED BOILER FURNACE.

It is of value to note that the samples which were tested for tenacity broke practically within the limits required by the rules when the material was made. In no case was the tenacity above, and in only a few instances was it below, the lower limit, and even in these few exceptions the difference was trifling and confined to those samples which were corroded or in which the surface and section was not uniform.

In the majority of cases, after the samples had been pulled asunder to determine the tenacity, the broken pieces could be bent cold through an angle of 180 degrees.

In pieces which were tested by bending only and not for tenacity, if the samples were sheared off by a machine in good order, they could in the majority of cases also be bent cold through an angle of 180 degrees.

The hot and forge tests were very satisfactory, even with the very corroded and damaged specimens. In many instances the pieces were hammered down very thin and to a chisel edge without any signs of fracture, and this also, in my opinion, is a very satisfactory result.

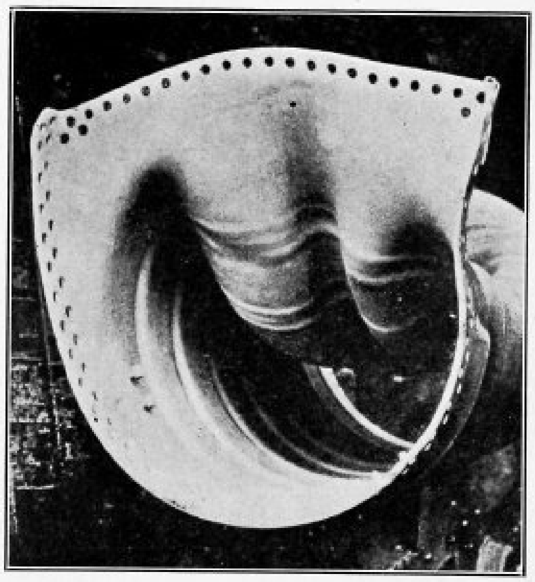
Samples which were cut from furnace plates which had been exposed for many years to the most intense heat stood the most severe mechanical tests.

The elongation of the material on a length of 8 inches was measured in all the pieces tested for tenacity and is considered satisfactory when allowance is made for damaged and corroded surfaces, and the variation in thickness and section at different portions of the length.

In regard to iron, the samples tested were not in any way so satisfactory as in the case of steel, working under the same conditions. Some of the old and thick samples, in fact, broke off in pieces directly they were touched by the shears.

In a paper which was read in 1881 at Newcastle-upon-Tyne before the Institution of Mechanical Engineers, a well-known shipbuilder, during the discussion, stated that he had to pay a good deal more for the material of an iron ship he had to build because it was specified that the iron should have an extension of 5 percent with and 2½ percent across the grain. This will give a good idea of what iron would stand at that time, and it is therefore of interest, in making a comparison, to know that if samples were now taken from mild steel ship plates which were made and tested twenty years ago and had been hard at work ever since, even if the material was damaged or much corroded, they would easily stand extension tests in any direction of double that amount.

With regard to corrosion in vessels, I have never been able to see any difference in its action between iron and steel of the same thickness. A half-inch plate of steel, if the conditions are similar, appears to withstand corrosion just as well as a half-inch plate of iron. In a corroded steel plate the part remaining will stand satisfactory tests; in a corroded iron plate it does not appear to do so.



DEPTH OF BULGE IN OVERHEATED BOILER FURNACE.

Twenty-five years ago the average life of an iron boiler was about ten years, while at the present time, with much higher pressures, it is at least double that. In a paper read before the Institution of Mechanical Engineers in 1878, Mr. W. Boyd, the first president of this institution, made the remark—"Time alone will prove whether this material (mild steel) can support the wear and tear of life on board ship." We now all know it does so uncommonly well, and for the purpose of record it may also be added that its quality and properties, after years of hard work, are practically unimpaired.

The early steel-makers who faced and solved the problem of making good mild steel at a moderate price, and shipbuilders like the late William Denny and others, who had the courage to use it, are really the men who are entitled to a great share of the credit for the progress which has been made in recent years. To continue this progress, further economy of material will be necessary, and this will no doubt be effected by the production and use of a still stronger and better steel.

The work on which this short paper is based is really due to many connected with the repair of vessels and the testing of steel.

SPECIMEN RESULTS OF TESTS OF OLD SIEMENS MARTIN, ACID OPEN-HEARTH BOILER PLATES WHICH WERE REMOVED OWING TO DAMAGE OR CORROSION.

DESCRIPTION.	Cause of Removal.	Age of Sample in Years.	Thickness.	Tenacity. Tons per Square Inch.	Elongation in 8 Inches. Percent.	Cold Bend Test. Angle Bent Through.	
Furnace	Overheating	8	.705	26.7	22	180°	
Do.	Do.	8	.725	27.5	24	180°	
Do.	Do.	8	.73	28.7	27	180°	
Do.	Do.	8	.75	28.6	26	180°	
Do.	Do.	12	.87	28.2	22	180° signs of fracture ar. 145°	
Do.	Do.	12	.83	26.3	27	180°	Hot bend and forge tests good.
Firebox	Corrosion	8	.62	27.3	28	180°	
Do.	Do.	8	.62	27.3	25	180°	
Bottom Front	Much do.	14	.65	25.5	13	180°	
Back end plates	New boiler fitted	25	.475	27.7	21	180°	
Do.	Do.	25	.48	28.5	24	180°	
Do.	Do.	25	.47	27.6	22	180°	
Back tube plate	Do.	25	.5	28.6	18	180°	
Do.	Do.	25	.495	29.3	20	180°	
Combustion back	Much corroded	13	.425	30.3	11	180°	
Do.	Do.	13	.52	27.8	16	180°	
Uptake	Corroded	13	.49	26.3	27	180°	
Do.	Do.	13	.56	26.4	22	180°	
Front tube plate	Do.	23	.54	27.5	27	180°	
Do.	Do.	23	.53	27.0	16	Surface pitted 135°-180° broken	
Chamber stays	Do.	7	.74 dia.	26.2	35 in 4"	180°	
Do.	Do.	7	.74 dia.	26.2	34 in 4"	180°	
Boiler shell	Wasted	16	.57	31.4	25	180°	
Do.	Do.	16	.57	31.9	23	180°	
Do.	Do.	16	.57	31.8	25	180°	
Do.	Do.	23	.42	26.7	15	Surface pitted 180°	
Do.	Do.	23	.42	26.9	24	180°	
Do.	Do.	23	.43	26.6	19	180°	

NOTE.—The bending tests were made on the broken pieces after the samples had been pulled asunder to determine the tenacity.

In the discussion following the reading of Mr. Heck's paper, Mr. William Boyd brought out the following interesting facts regarding the material used in the construction of a boiler installed in one of the first ships to be built wholly of steel. The boiler was 13 feet 3 inches in diameter and 10 feet 8 inches long. Heating surface 1,880 square feet, and working pressure 65 pounds. The design being submitted to Lloyd's in the usual way, they agreed to a certain reduction of thicknesses "as an experiment only" and on certain conditions, viz.:

1. That the plates should have a tensile strength of from 26 to 30 tons.

2. That a specimen of the longitudinal joint should be tested and shown to have a percentage of 74 percent of the solid plate.

3. That a shearing of every plate should be subjected to bending or tempering tests.

4. That the flat surfaces should be shown by experiment under hydraulic pressure—when stayed in the usual manner—to be as strong to resist buckling as ordinary iron plates.

These experiments were duly carried out with the assistance of Mr. Manuel, Lloyd's surveyor, and were recorded in the paper in question, but they would hardly interest you now. Suffice to say that the design was passed for 65 pounds pressure, with the following reductions in thicknesses:

		Reduction, Percent
Boiler-shell plates, from...........	7/8 to 11/16 inch	21.43
Boiler ends	3/4 to 9/16 inch	25.0
Furnaces and combustion chambers,	1/2 to 7/16 inch	12.5
Front and back tube plates.........	3/4 to 11/16 inch	8.33

The experiments then carried out under the supervision of Lloyd's Registry may be said to have formed the basis of their present rules for the thicknesses of steel boiler plates, which, at a date subsequent to 1878, were issued to engineers and boiler makers engaged in the construction of marine boilers. Up to this time they had no rules for scantlings, and, as I have before explained, the reductions in thickness from the ordinary iron plates were allowed in this case "as an experiment only." If the same boiler were to be built now under Lloyd's *present* rules, there would be a further slight reduction of about 4½ percent in the shell plates and about 11 percent in the boiler ends. The inside work would remain pretty much the same. This shows that the advisers of Lloyd's Register thirty years ago were not very far off the mark.

The plates for the boiler were made by the late Mr. C. W. Siemens at the Landore Steel Company's works in South Wales, and, as before stated, were to have a tensile strength of from 26 to 30 tons. They were shown by test to have an actual mean breaking stress of 28.7 tons with an elongation of 26.5 percent of length.

It is interesting to compare this tensile strength of 26 to 30 tons with that of the high tensile silicon steel plates used in the boilers of the *Mauretania*, which, as you will see in "Engineering," had a tensile strength of about 37 tons, an elongation of 21 percent and elastic limit of 21.8 tons. The success which attended these early efforts thirty years ago is evident to all engineers to-day, and the behavior of the material under great "provocations" is also well known, and is well brought out by the figures given in Mr. Heck's paper.

Mr. J. L. Twaddell said: Although Mr. Heck's subject deals with the effect of work and time on the properties of mild steel and iron, I think it is to be regretted he did not give us some results of his experience in regard to the riveting attachments as well as the material itself. It might be said, of course, that little or no opportunity of determining the relative value of iron or steel rivets is available in vessels of the merchant service, on account of the almost universal practice of using rivets of iron only in steel ships, although steel rivets are used in boilers, and I regret I am unable to augment Mr. Heck's paper in this direction, although some other member may be able to do so. I would, however, suggest that, apart from the theoretical strength of a riveted joint, the effect of work and time on the material of which the rivets are made deserves some serious consideration.

The Admiralty practice is to have rivets of the same material as the plates they connect, hence mild steel rivets for mild steel plates and high-tensile steel rivets for high-tensile plates. No doubt this practice is the result of careful consideration, but it would be interesting to know how far this practice is justified by experience of the effect of work and time on the material forming the rivets. It seems reasonable to take into consideration the fact that while the quality of the material of the bars used for making rivets is the same as that of the plates, these bars have to be heated and worked into the form of the rivet, and again heated and hammered up in the structure, so that the finished rivet may not have quite the same quality as the bar from which it was made possessed. Again, it should be borne in mind that a very large percentage of the rivets in the main structure of a ship's hull are subject to shearing stress rather than tensile. In order to test in a small way the relative value of high-tensile steel, mild steel and iron rivets, I recently made a little experiment in our test house at the Jarrow yard in the following manner:

Two pieces of plate, 9 pounds per foot, connected together with a butt strap 11 pounds per foot, riveted by three half-inch diameter rivets each side of butt placed lengthwise in the plate as in a treble-riveted strap. With high-tensile plate and high-tensile rivets, the plate fractured at 19.4 tons, but the rivets did not shear. With a mild steel plate and mild steel rivets, prepared as already described, the rivets sheared at 16 tons. With mild steel plate and iron rivets, the rivets sheared at 14.7 tons. Then, in order to test similar rivets in tension, I had two smithed eyeplates riveted together with two half-inch diameter rivets and pulled them apart. The iron rivets broke at 10.35 tons; the high tensile at 18.05 tons, and the mild steel rivets at 18.5 tons, a noticeable feature being that while the high-tensile rivets broke clean off at bottom of countersink, the mild steel and iron rivets sheared the countersink off almost in the form of a washer. You will also notice that the mild steel rivets, probably from the stress exerted in shearing off the countersink, withstood a greater strain than did the high-tensile rivets which broke. I may say that the high-tensile steel used in both plates and rivets was tested to 37 to 43 tons per square inch tensile, with an elastic limit of not less than 22 tons and a minimum elongation of 18 percent on 8 inches. The mild steel was of the usual Lloyd's tests. So that you can make your own deductions. The bars from which the iron rivets were made were of the usual rivet bar quality.

Lloyd's Register Boiler Rules.

(Continued from p. 48, February Boiler Maker.)

TABLE FOR FINDING THE DIAMETERS OF RIVETS AND OF PITCHES IN RIVETED JOINTS.

A short table is given in this column which shows the smallest permissible percentage for any form of joint, the condition being that when that particular percentage is ádopted the strength of the joint shall be exactly the same for each

TABLE OF LEAST PERCENTAGES OF RIVETED JOINTS.

m*	1¼	1⅓	1½	1⅔	1¾	2	2¼	2½
Lap joint, 3 rows......	....	52.6	63.6	71.0	73.7	80.0	84.2	....
" " 4 "	53.0	60.8	71.4	78.1	80.5	85.7	....	....
" " 5 "	60.2	68.2	78.4	84.7	86.5	....	....	....
" " 6 "	65.6	73.8	82.6	87.9	....	....	....	....
" " 7 "	70.5	77.9	86.6	....	....	....	....	....
" " 8 "	74.2	81.2	....	....	....	....	....	....
Butt joint, 2 rows......	....	....	55.5	63.9	67.3	75.0	80.2	87.1
" " 3 "	....	57.8	70.4	78.4	81.4	87.5	....	....
" " 3 "	1½ in each inner row } 66.7			2 in each inner row } 83.33			....	

* m = quotient of the number of rivets in one row, when divided by the number in the adjoining inner row.

row of rivets. If this percentage is exceeded, the inner rows will be stronger than the outer ones. If the joint is made of a smaller percentage, the inner rows of rivets will be weakest and must be calculated separately.

Having decided on a particular percentage, the best dimensions of the joint can be ascertained from the following table, which contains the values of $M \times D \div T =$ number of rivets $\times$ diameter of rivets $\div$ thickness of shell plate. Having found the number in the table against the desired percentage, it is only necessary to multiply it by the thickness of the plate and then, dividing by the number of rivets within one pitch, their diameters are found. The percentage and, therefore, also the numeral should be so chosen that the latter is larger than the number of rivets in one pitch.

Example.—Butt-strap joint 1-inch steel plates, steel rivets, three rows, with two rivets in each inner row. Then the smallest percentage to be adopted for this joint is 83.33. Interpolating the values in the following table, it will be found that the value of $M \times D \div T$ is 4.28. Dividing this by 5, the number of rivets, then their diameters must be .856. In the first column of the same table will be found the value of pitch $\div$ rivet diameter $= 6$. Therefore the pitch is $6 \times .856 =$ 5.136 inches.

If it is desired to make the rivet diameter equal to the thickness of the plate, then a value must be selected where $M \times D \div T = 5$, *i. e.*, 85⅔ percent; then the pitch would have to be 6.98 inches.

TABLE FOR VALUES OF M × D ÷ T.

Pitch ÷ Rivet Diameter.	Percentage of Plate.	Lap Joint. Punched. Iron Plates. Iron Rivets.	Lap Joint. Drilled. Iron Plates. Iron Rivets.	Lap Joint. Steel Plates. Steel Rivets.	Lap Joint. Steel Plates. Iron Rivets.	Butt Straps. Punched. Iron Plates. Iron Rivets.	Butt Straps. Drilled. Iron Plates. Iron Rivets.	Butt Straps. Steel Plates. Steel Rivets.	Butt Straps. Steel Plates. Iron Rivets.
		Constants.							
		100	90	85	70	7/4 x 100	7/4 x 90	7/4 x 85	7/4 x 70
2.50	60	....	2.12	2.25	2.73	....	....	....	....
2.56	61	....	2.21	2.34	2.84	....	....	....	....
2.63	62	2.08	2.31	2.44	2.97	....	....	....	....
2.70	63	2.17	2.41	2.55	3.10	....	....	....	....
2.78	64	2.26	2.52	2.66	3.23	....	....	....	....
2.86	65	2.36	2.63	2.78	3.38	....	....	....	....
2.94	66	2.47	2.75	2.91	3.53	....	....	....	2.02
3.03	67	2.59	2.87	3.04	3.69	....	....	....	2.11
3.12	68	2.71	3.01	3.18	3.87	....	....	....	2.21
3.23	69	2.83	3.15	3.33	4.05	....	....	....	2.31
3.33	70	2.97	3.30	3.49	4.24	....	....	....	2.42
3.45	71	3.12	3.46	3.66	4.45	....	....	2.10	2.54
3.57	72	3.27	3.64	3.85	4.68	....	2.08	2.20	2.67
3.70	73	3.44	3.82	4.05	4.92	....	2.19	2.31	2.81
3.85	74	3.62	4.03	4.26	5.18	2.07	2.31	2.44	2.96
4.00	75	3.82	4.24	4.49	5.46	2.18	2.43	2.57	3.12
4.08	75½	3.92	4.36	4.61	5.61	2.24	2.49	2.64	3.20
4.17	76	4.03	4.48	4.74	5.76	2.30	2.56	2.71	3.29
4.26	76½	4.14	4.61	4.87	5.92	2.37	2.63	2.79	3.38
4.34	77	4.26	4.74	5.01	6.09	2.44	2.71	2.87	3.48
4.44	77½	4.38	4.87	5.16	6.27	2.51	2.78	2.95	3.58
4.55	78	4.51	5.02	5.31	6.45	2.58	2.86	3.03	3.68
4.65	78½	4.65	5.17	5.47	6.64	2.66	2.95	3.12	3.79
4.76	79	4.79	5.32	5.64	6.84	2.74	3.04	3.22	3.91
4.88	79½	4.94	5.49	5.81	7.05	2.82	3.13	3.32	4.03
5.00	80	5.09	5.66	5.99	7.28	2.91	3.23	3.42	4.16
5.13	80½	5.26	5.84	6.18	7.51	3.00	3.33	3.53	4.29
5.26	81	5.43	6.03	6.39	7.75	3.10	3.44	3.65	4.43
5.40	81½	5.61	6.23	6.60	8.01	3.21	3.56	3.77	4.58
5.56	82	5.80	6.44	6.82	8.29	3.32	3.68	3.90	4.73
5.71	82½	6.00	6.67	7.06	8.57	3.43	3.81	4.04	4.90
5.88	83	6.22	6.91	7.31	8.88	3.55	3.94	4.18	5.07
6.06	83½	6.44	7.16	7.58	9.20	3.68	4.08	4.33	5.26
6.25	84	6.68	7.43	7.86	9.54	3.82	4.25	4.49	5.46
6.45	84½	6.94	7.71	8.17	9.92	3.97	4.41	4.67	5.67
6.67	85	7.22	8.02	8.49	10.31	4.12	4.58	4.85	5.89
6.82	85⅓	7.41	8.23	8.72	....	4.23	4.70	4.98	6.05
6.98	85⅔	7.61	8.46	8.95	....	4.35	4.83	5.12	6.21
7.14	86	7.82	8.69	9.20	....	4.47	4.97	5.26	6.38
7.32	86⅓	8.04	8.94	9.46	....	4.60	5.11	5.41	6.57
7.50	86⅔	8.28	9.20	9.74	....	4.73	5.25	5.56	6.76
7.69	87	8.52	9.47	10.02	....	4.87	5.41	5.73	6.96
7.89	87⅓	8.78	9.75	....	....	5.02	5.57	5.90	7.17
8.10	87⅔	9.05	10.06	....	....	5.17	5.75	6.08	7.39
8.33	88	9.34	....	....	....	5.33	5.93	6.28	7.62
8.57	88⅓	9.64	....	....	....	5.51	6.12	6.48	7.87
8.82	88⅔	9.96	....	....	....	5.69	6.32	6.70	8.13
9.09	89	10.30	....	....	....	5.89	6.54	6.93	8.41
9.37	89⅓	....	....	....	....	6.09	6.77	7.17	8.70
9.68	89⅔	....	....	....	....	6.31	7.01	7.43	9.02
0.00	90	....	....	....	....	6.55	7.28	7.70	9.36

Comparison of Rules for Calculating the Strength of Steam Boilers.

The object of this paper is to attract the attention of engineers to variations in the rules now in use for determining the strength of the different parts which make up a steam boiler, with the hope that it may elicit a full discussion of the question whether or not it is desirable to prepare a set of standard rules for strength.

Universal standards, based on scientific methods coupled with experiment and experience, are now being adopted with advantage by both engineering and commercial interests.

Engineers have accumulated sufficient experience to predict with accuracy results that can be expected. Such predictions as to strength of boilers are foretold by calculations founded on analytical science, with constants supplied by experiment. Engineering literature is rich with records of these experiments, and the results obtained are in close enough accord for all practical purposes.

The author will not attempt a complete analysis of the rules in force, as most engineers are fully aware of the discrepancies, but will simply compare a few rules for the sake of illustration.

DATA ASSUMED.

Type of boiler, Scotch.

Mean diameter, 12 feet 7 inches = 151 inches.

Working steam pressure, 130 pounds above atmosphere.

Material, steel.

Material, tensile strength, 60,000 pounds.

Thickness of shell, 7/8 inch.

Joints, longitudinal. Double butt straps of equal width, double riveted.

Joints, transverse, lapped, double riveted.

Rivets, material, steel.

Rivets, diameter, 1 inch.

Rivets, pitch, 4 inches.

Flat heads, steam space, thickness, 3/4 inch.

Long stays, steel, spacing, 15 inches.

Long stays, fastening, double nuts, thinnest washer allowed.

Stay-bolts, spacing, 8½ inches.

Stay-bolts, fastening, screwed, single nuts.

From the above data the working pressure allowed on the shell in pounds per square inch would be as given in Table I.

TABLE I.

I.	United States Board of Supervising Inspectors of Steam Vessels	139.0
II.	Lloyd's Rules	116.8
III.	Board of Trade	111.0
IV.	British Corporation	118.6
V.	Bureau Veritas	110.8

The difference is 28.2 pounds, or over 25 percent.

The first rule makes no allowance for workmanship or proportions of joints. The other four rules include the percentage of strength of joint, while the third rule has a sliding scale for workmanship, shop methods and general design.

The working pressure allowed on the flat heads in the steam space, when not exposed to the hot gases, and when the stays are fitted with double nuts and a washer on the outside, riveted to head and of minimum thickness mentioned in the rule, would be given in Table II.

TABLE II.

I.	United States Board of Supervising Inspectors of Steam Vessels	184.3
II.	Lloyd's Rules	128.0
III.	Board of Trade	144.3
IV.	British Corporation	127.9
V.	Bureau Veritas	130.9

The difference is 56.4 pounds, or over 44 percent.

The rules are not alike as to the size and thickness of the minimum riveted washer mentioned, and consequently the variation is largely due to the value of the constant employed.

Taking the data as assumed, and making the calculations for a working pressure of 130 pounds, the results for the parts specified would be as given in Table III.

TABLE III.

Part of Boiler.	I. United States S. I. S. V.	II. Lloyd's Rules.	III. Board of Trade.	IV. British Corporation.	V. Bureau Veritas.
Thickness of shell, ins.	0.8229	0.9594	1.0239	0.9532	1.0201
Nearest 32d	27/32	31/32	1 1/32	31/32	1 1/32
Thickness of flat surfaces, screw staybolts, 8½ inch centers, fitted with nuts, inches	0.5531	0.5531	0.52232	0.5338	0.4842
Nearest 32d	18/32	18/32*	17/32	17/32	15/32
Area of long steel stays, square inches	3.656	3.656	3.250	3.262	3.259
Diameter, nearest 16th	2 3/16	2 3/16	2 1/16	2 1/16	2 1/16

*17/32 is too thin, but for 18/32 pressure could be 151 pounds, or nearly 17 percent more than required.

Certain essential details are not provided for by some of the regulations, but are in others. Some inflict penalties for poor workmanship and defective design, while others allow the same pressure on the best as well as the poorest boiler when made from the same material. Corrosion is provided for by the addition of a fixed thickness to the calculated part under some regulations, while in others it is included only in the general factor of safety. This factor of safety necessarily differs in all the regulations.

The author is not aware that there have been any more failures under the regulations giving the minimum thickness than under those of the maximum. If the minimum is ample, why use the maximum? If, under the high pressures now maintained, the maximum is needed for safety, is it not opportune to increase the minimum? If the minimum is sufficient, then from Table III. it will be apparent that under any one regulation the boiler is not of equal strength throughout its parts, nor is there the same allowance for the more rapid corrosion of certain parts over others. Thus, if the shell thickness under Regulation I. be correct, it is not necessary to have it as heavy as under Regulations III. and V., while the staying of Regulations III. and V. are lighter than in Regulation I.

The above data and facts have been taken from a paper read by Mr. H. De B. Parsons a few years ago before the American Society of Mechanical Engineers. Mr. Parsons is a consulting engineer who is recognized as an authority on steam-boiler construction. The wide variations and discrepancies between the various so-called standard rules for determining the size and strength of steam boilers are just as great to-day as they were at the time this paper was written. The worst offenders, the rules prescribed by the Supervising Inspectors of the United States Steamboat Inspection service, have remained practically unchanged, while foreign rules are continually being modified as is deemed expedient from experience.

In the discussion brought out at the time Mr. Parsons' paper was read, Mr. R. S. Hale, consulting engineer for the Mutual Boiler Insurance Company, explained the practice of this company in determining the strength of boilers and showed how their experience had brought out the difficulty of establishing a set of standard rules which could be applied to all conditions.

Taking up first the question of the cylindrical shell (he said), I will refer to the horizontal return tubular boiler, as by far the great majority of boilers which come under our inspection are of this type.

The factors covering the pressures to be allowed on these boilers are thickness of the plate, the strength of the metal, the efficiency of the joint, and what may be called the moral factors, such as the design of the boiler, the workmanship during construction, and the use to which the boiler is put. In regard to the efficiency of the joint, we always compute this from the strength of the metal and of the rivets. We do not, however, often find it necessary in new boilers with butt-strapped joints to consider particularly the strength of the rivets in shear, since, if the joint is properly designed for a tight joint, the rivets are usually much stronger than the plate. On lap joints this is not necessarily the case, but lap-joint boilers are now very seldom put in by our members, except for heating purposes, where the pressure carried does not exceed 15 pounds per square inch, and where the margin of strength is very high.

In regard to the tensile strength of the metal, it is our custom to specify that the tests of coupons in the sheets shall not be less than a certain amount, usually 55,000 pounds per square inch, nor more than a certain amount, usually 65,000 pounds per square inch. We also specify that the elongation in 8 inches shall not be less than a given amount, usually 25 to 30 percent, and that the phosphorus and sulphur shall not exceed certain limits, usually .035 percent. These requirements represent the usual mild steel specifications.

We make no allowance for future corrosion in the design of the boilers, except in so far as we use a lower unit stress in designing than we consider safe, so that even with some slight corrosion the boiler can still be run at the pressure for which it is designed.

In regard to stayed surfaces, we have two cases to consider. First, in horizontal tubular boilers. In these we stay the heads preferably with through and through rods of large size, say of about 2 inches diameter, with channel bars or angle bars riveted to the heads to stiffen them. On these rods we allow a stress of 9,000 pounds per square inch.

On the fire-box of vertical tubular boilers we have usually adopted the United States rule. This gives the highest pressure of any of the rules in common use, but even in large boilers with the fire-box 6 or 7 feet in diameter, the fire-box is, to a certain extent, self-sustaining, so that we have thought the rule gave ample margin, particularly as we know of very few cases of failure of boilers at this point.

On small vertical tubular boilers, of which we have quite a number under inspection, even the United States rule would require a very much larger number of stays than is found practically necessary. We have had occasion to design but very few small boilers of this type, as most of the boilers under our inspection were already at work when brought to us for approval or to determine a pressure. In the latter cases we have computed the permissible pressure by the United States rule, and also the permissible pressure considering the fire-box as a collapsible flue. If the sum of these two pressures, *i. e.*, the pressure which the fire-box will carry as a collapsible flue, added to the stiffening effect of the stays, was greater than the pressure which the user of the boilers desired to carry, we have considered ourselves safe in allowing that pressure, and have never had any difficulty.

As will be seen from the above statement, there would be great difficulty in adopting any rules which could take into account all the different factors of different qualities of metal, different design of joints, different grades of workmanship, different allowances for corrosion, and differing services for which the boilers are to be used. At the same time full discussion of all these questions would be of great value to designers and insurers of boilers.

Mr. F. A. Scheffler commented as follows: Personally, I believe that the best rule as to strength of shells is the one used by the Board of Trade, as the strength of joint is taken into consideration, which, in my opinion, is the only proper way to obtain the true strength of the shell. It is surprising that, with all the brains which our government has at its command, no one at Washington has had the sense to correct or revise the loose rule now in existence for determining the strength of the shells.

This rule is so old that you can almost see the gray hairs on it. It is wrong in more ways than one, but I call attention to the fact that 20 percent is not always the increase in strength of the joint by double riveting. One can design a joint in double riveting which will only increase the strength 10 percent, or which will increase it 30 percent, if the single-riveted joint with which it is compared is a bad one. Query: Does the department allow 30 percent additional pressure for a triple riveted joint?

On the other hand, the Board of Trade's Rules for flat surfaces is not so conservative, and some of the others are better.

Prof. H. W. Spangler.—It would seem to me that this question is largely a question of insurance. As far as the United States rules are concerned, they are those rules which must be followed by vessels which are to be used in the navigable waters of the United States. If you are going to insure in a particular company, you want to build what that particular company is willing to insure after it is built. If you are willing to insure yourself, it seems to me you should design as you know is right, if you do know. I am satisfied that the rules of the United States Supervising Inspectors are far from being the best rules for the building of boilers which can be devised; but those of us who have had to deal with the foreign insurance companies, and have kept track of their rules for years, know that those rules are constantly being modified by their experience, while the United States rules are not. Therefore, if one wants to insure his boilers it seems to me it is nothing more than sensible that he should build his boilers as insurance companies call for.

Mr. William Kent.—In regard to the United States rules, I think they have been condemned by every authority who has ever written on the subject. They are known to be less safe than any other rules, and the foreign rules, the Board of Trade, Lloyds, the Bureau Veritas and others are, as Prof. Spangler says, being constantly modified by experience, while the United States rules are not modified by experience or anything else. They have been condemned by writers for the last twenty-five years, and they remain in the same old fossilized condition in which they always have been, with the single exception known to me, that a few years ago the Board of Supervising Inspectors did discover, twenty years after the people had discovered it, that the neck form of test piece was not a good one for steel. I believe the rules still allow that neck form for iron. Years ago it was not good for either iron or steel, and the United States Board of Supervising Inspectors only four or five years ago did find out that it was not good for steel.

The experience of the insurance companies of this country and the experience of foreign countries is that boilers ought to be built about as these foreign rules lay down. And they do not differ so much among themselves. For instance, the working pressure allowed on the flat heads, when not exposed to the hot gases, and when the stays are fitted with double nuts and a washer, etc., is 127, the British Corporation, and 144, Board of Trade, the two extremes, while the United States rules give 184 pounds. The working pressure allowed on the shell in pounds per square inch varies from 110 to 118 according to the foreign rules, while the United States rule gives 139 pounds. So the United States rule is the only one which is very far away. I think, if we want to build boilers, if we build them according to foreign rules or according to the rules of the American insurance companies, they will be all right.

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.

The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Standard Rules for the Strength of Boilers.

There are few parts of a steam boiler the strength of which can be calculated exactly. By assuming that the shell satisfies the conditions of a thin, hollow cylinder, and that the stress produced in it by an internal fluid pressure is uniformly distributed throughout the thickness of the metal, the strength of the shell can be accurately calculated. The strength of stays and braces can be calculated exactly only by assuming that the stresses produced in them are purely direct tensile stresses. In the case of short stays connecting flat surfaces we know that this is not the case, and that where there is unequal expansion between the two surfaces, and the bolts are rigidly fixed at each end, this unequal expansion causes bending stresses, in addition to the direct tensile stress. The intensity of these bending stresses can not be accurately determined. The strength of flat plates supported at regular intervals can not be calculated with any degree of accuracy, since all such calculations are based on formulæ for the theoretical stress in plane surfaces uniformly loaded and supported at equally spaced points of infinite strength. These formulæ are derived from a somewhat incomplete knowledge of the theory of the elasticity and can not be said to represent actual conditions in practice. Formulæ intended to cover such conditions nearly all have the same general form, but differ in the matter of the value of the constants employed and therefore give slightly different results. Such formulæ can not be depended upon in extreme cases, but within ordinary limits give results which agree fairly closely.

Since the strength of most parts of a steam boiler must be determined by formulæ which are themselves more or less empirical, it is not strange that the rules prescribed by different authorities give results which vary widely. This point is brought to mind emphatically by the article published elsewhere in this issue, showing how, in a specific case, widely different values are obtained for the strength of a certain boiler when figured according to different rules. This article is an abstract of a paper which was read a few years ago before the American Society of Mechanical Engineers for the purpose of bringing out discussion on the question of whether or not it would be advisable for the society to recommend a set of rules which could be adopted as standard for calculating the strength of steam boilers. Nothing was done by the society at that time towards framing and adopting such rules, although the comments brought out during the discussion of the paper showed that for many reasons such a standard would be welcome.

Although different rules, now recognized as authorities, would give values for the allowable steam pressure to be carried by the shell of a certain boiler which would vary by as much as 25 percent, and values for the allowable working pressure to be carried by stayed flat surfaces which would vary by as much as 44 percent, yet it should not be inferred that boilers built to the rules which give these extreme values are unsafe. Boilers built to any of these rules are doubtless perfectly safe, but it is evident that if the minimum values are sufficient, a needless expense has been involved in building a boiler to conform to rules with more stringent requirements.

The worst feature about some of the rules now in existence is, that it is almost impossible to have them modified or changed to conform with the changes made in the quality of material and style of construction used in modern boiler making. Most of the foreign rules can be, and are, so modified to conform with current practice, but the rules prescribed for marine boilers in the United States seem to be almost impregnable. Probably more has been done by the American Boiler Manufacturers' Association than by any other one body of men towards changing these rules. It is practically impossible to obtain a general revision of the law as it now stands, as that must be done by Congress, upon the recommendation of the Secretary of Commerce and Labor. But it has been found possible to change certain sections of the law by taking them up one at a time and having them revised at the annual meeting of the Board of Supervising Inspectors. After considerable difficulty the Boiler Manufacturers' Association succeeded in obtaining the standard 8-inch gage length test piece for use in testing steel plates, and were thus able to obtain the proper values for the tensile strength of plate, which could not be done under the old neck form or short 3-inch specimen.

One of the best mediums for framing and establishing a set of standard rules for the strength of steam boilers is the International Master Steam Boiler Makers' Association, which meets for its annual convention the latter part of May. The Master Boiler Makers are in a position to frame a desirable set of rules to represent current practice and could, without doubt, succeed in having them recognized by various insurance companies and other authorities as a standard. Such an action, it seems to us, would be eminently desirable and beneficial to the industry.

Convention Announcement.

The officers of the Boiler Makers' Supply Men's Association and members of the entertainment committee met in Detroit Feb. 29 and arranged a program of entertainment for the forthcoming convention of Master Steam Boiler Makers. This program includes automobile rides, a boat excursion and banquet, besides minor forms of entertainment, such as theater parties, etc., for the ladies and guests of the association.

Headquarters of the Master Boiler Makers' Convention for 1908.

The first annual convention of the International Master Steam Boiler Makers' Association, which was formed last year, is to be held May 26, 27, 28 at the Hotel Pontchartrain, Detroit, Mich. The association is to be congratulated upon the fact that this convention is to be held in one of the finest hotels of the Middle West. The Hotel Pontchartrain was opened to the public Oct. 29, 1907, and is therefore practically a new structure and embodies all the finest appointments of an up-to-date modern hotel.

The name of the Hotel Pontchartrain has an historic significance, from the fact that Count Pontchartrain, who was Prime Minister of France during the reign of Louis XIV., sent the

THE HOTEL PONTCHARTRAIN.

Chevalier de la Mothe Cadillac upon an expedition of discovery and colonization to America. In 1701 Cadillac founded what is now the city of Detroit, and built a log fort, calling it Fort Pontchartrain. The name, therefore, antedates even the present name of the city, Detroit.

The hotel is absolutely fireproof and contains 300 rooms beautifully and artistically decorated and furnished. The rooms are all of good size, and each has its telephone, sunk into the wall. Each is tasteful in the harmony of its furnishings, and nearly all are furnished in mahogany. Of the 300 rooms, 178 have baths. On each of the floors above the ground is an arrangement, intended to keep out noise from the other floors and from the opening and closing of the doors of the elevator. It is a glass-enclosed vestibule surrounding the elevator entrance, through which no noise can pass.

The general effect of the decorations in the hotel is simplicity and dignity. In the main lobby the pillars and wainscoting and the grand stairway leading to the second floor are of mottled black and white marble. The wood is a gray traced with silver. One end of the long lobby is designed for a public parlor. At the eastern end of the lobby is a ladies' café, daintily finished in buff and gold, and adjoining it is the men's café, which is a great vaulted room, finished in old oak, made to represent gray stone. The light is quiet and subdued and the impression one gets of the room is that of the dining hall of some old feudal castle whose heavy oaken beams have held the ceiling for centuries.

Between the men's café and the lobby is the lounging room. This is also known as the flamingo room, on account of a brilliant panel on which flamingoes are pictured against a golden sky. The flamingo red prevails throughout the room; the woodwork is of Circassian walnut, exquisitely matched.

THE FLAMINGO ROOM.

Throughout the main lobby and the parlors on the floors above are scattered splendidly designed and finely upholstered chairs and other pieces of furniture. Comfort, combined with artistic and classic design, is the principal feature of all the furniture in the hotel.

Not only are the decorations and arrangements for the comfort of guests of interest, but the hotel includes a mechanical equipment of no small proportions. One unusual feature of this equipment is the fact that there are no boilers in the building. All power, either steam or electrical, is derived from outside sources. In the sub-basement, pumps of large capacity

THE MAIN CAFE.

are located, which draw the air down the shafts and force it again through purifying cloths to every part of the great building. Clean air is good, not alone for the guests, but for the proprietors, saving dust and dirt and many a cleansing operation.

Here, also, is the power for compressing air to clean every floor of the hotel, for each story is equipped with pipes and apparatus for sucking up the dust, which is then drawn into the sub-basement. Near by are the great filters through which passes every drop of water entering the hotel, whether for bathing, drinking or the washing of dishes. Filtered water is heated in great reservoirs ready for instant use.

Switchboards for controlling both the telephone system and the distribution of power are located here, as are also the laundry, bake shops, wine vaults, etc.

On the basement floor proper are located the kitchens, refrigerating rooms, store rooms, and in the front part of the building the billiard room and convention hall. This hall is supplied with a rostrum and room for 350 chairs, and is frequently used as a banquet hall.

The hotel is conducted upon the European plan. The room rates are well graduated and moderate, ranging from $2.00 upwards per day. As already stated in a previous issue of The Boiler Maker the rates will be as follows: Single room without bath, $2 and $2.50 a day; two persons in a room without bath, $3, $3.50 and $4; single room with bath, $3, $3.50, $4 and $5; two in room with bath, $5, $6, $7 and $8. The use of the convention hall and three committee rooms is to be given without charge.

PERSONAL.

A. H. Swartz, formerly connected with the Carnegie Steel Company's and Republic Iron & Steel Company's plants at Youngstown, Ohio, and having a wide acquaintance among operators of power plants throughout the country, has taken a position on the selling force of the Rust Boiler Company, Pittsburg, Pa.

Peter Brown, a retired furnace builder and iron manufacturer, died at Allentown, Pa., Feb. 3, aged 83 years. He built many blast furnaces in Pennsylvania, New York and New Jersey.

A. R. Hodges, formerly assistant foreman boiler maker of the Texas & Pacific Railroad, at Marshall, Tex., has accepted the position of foreman boiler maker of the F. C. I. R. R., of Mexico, with headquarters at Pueblo, Mexico.

TECHNICAL PUBLICATION.

Proceedings of the Nineteenth Annual Convention of the American Boiler Manufacturers' Association of the United States and Canada. Size, 5½ by 8½ inches. Pages, 114. Illustrated.

The proceedings of the nineteenth annual convention of the American Boiler Manufacturers' Association, which was held at the Piedmont Hotel, Atlanta, Ga., Oct. 8, 9 and 10, 1907, have been carefully edited and published in pamphlet form by the secretary of the association. Besides the proceedings of the association, including the papers which were read and the discussion which was carried on, the pamphlet contains photographs of all the officers of the association, lists of standing committees, and also complete information regarding the Supply Men's Association, which has hitherto provided the entertainment features at the conventions. The subjects of the papers included in this book are Boiler Materials, Revision of Marine Laws, Is the Sudden Stopping of High-Pressure Marine Engines Detrimental to the Boiler? The Boiler Inspector, Spacing of Flues and Cold Water Testing.

During the first eight months of 1907 the total value of locomotives exported from Great Britain equaled $10,809,635, of which $5,858,141 worth were sent to South America, $2,982,457 worth to British India, $284,625 worth to Spain, $145,328 to the Straits settlements and $168,967 to Australasia.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Will you please advise me through the columns of your valuable paper of the requirements of the various States of the Union and of Mexico for the factor of safety to be used in figuring the working pressure of steam boilers? "L."

A.—There are very few States which prescribe any rules for the construction of steam boilers. Therefore the factor of safety to be used in figuring the working pressure of steam boilers is not specified except as the boiler must satisfy the specifications to which it is built, and the inspectors of the insurance company by which the boiler is insured.

Some cities in the United States have laws governing the inspection and construction of boilers. These cities generally frame their boiler laws in accordance with the United States marine boiler law, which are the only Federal laws in existence covering boiler construction. This has been the case in Chicago, Cincinnati, Pittsburg and St. Louis. The United States marine laws specify that the factor of safety of 6 shall be used, but this is intended to cover the weakness at the riveted joint, since no account is taken of the strength of the joint in figuring the working pressure, except to add 20 percent in the case of a double-riveted lap joint. After making due allowance for the weakness at the seam, the real factor of safety provided by the United States marine laws is really probably between 3½ and 4.

The State of Massachusetts has recently passed a law providing for a board of boiler rules to formulate rules for the construction of all steam boilers installed in the State. This board has already published a set of rules governing boiler construction and specifying that the factors of safety to be used shall be as follows:

"The lowest factors of safety used for steam boilers the shells or drums of which are directly exposed to the products of combustion, and the longitudinal joints of which are of lap-riveted construction, shall be as follows:

"(a) Five (5) for boilers not over ten years old.

"(b) Five and five-tenths (5.5) for boilers over ten and not over fifteen years old.

"(c) Five and seventy-five hundredths (5.75) for boilers over fifteen and not over twenty years old.

"(d) Six (6) for boilers over twenty years old.

"(e) Five (5) for steam boilers the longitudinal joints of which are all lap-riveted construction and the shells or drums of which are not directly exposed to the products of combustion.

"(f) Four and five-tenths (4.5) for steam boilers the longitudinal joints of which are of butt and strap construction."

The foregoing rules have only recently been framed and represent the work of an experienced and highly trained body of men, so that they may be taken as representative values without much chance for error.

Although few States prescribe a set of rules covering boiler construction, a number of States and nearly all large cities have on their city statutes laws governing the inspection of boilers. Such laws are in force in Connecticut, Colorado, Indiana, Massachusetts, Vermont, Tennessee, New York, Pennsylvania, Maine, Illinois, etc. A factor of safety of 5 is usually used by inspectors appointed under these various laws when fixing the safe working pressure which may be allowed on the boilers under their supervision.

Q.—Will you please show me how to lay out the base for a smokestack, one end of the connection being oblong and the other circular, the center of the stack being located directly over the oblong base? M. G.

A.—Fig. 1 shows a plan and elevation of a connection with an oblong base and a round top. The diameter of the round end is shown to be 40 inches, which is the inside diameter of the stack. The first thing to be done in the layout is to determine the dimensions of the oblong base of the connection, so that the area of the opening at this end will equal the area of the opening in the circular end. Since the circular end is 40 inches in diameter, this area will be $(40)^2 \times .7854$, which equals 1,257 square inches.

Assuming that the oblong base will be 24 inches wide, or slightly more than one-half the diameter of the stack, find what length is necessary in order to give the required area of the opening. The oblong base can be divided into a rectangle and two semi-circular ends, which, if placed together, would form a complete circle 24 inches in diameter. The area of these ends, therefore, equals $(24)^2 \times .7854$ or 452 square inches. Subtracting 452 square inches from 1,257 square inches leaves 805 square inches as the area of the rectangular part of the opening. Since the width of this is 24 inches, its length must be $\frac{805}{24}$ or about 33½ inches.

Having determined the size of the oblong opening, draw this in the plan view, according to these dimensions, and then it will be seen that we have an irregular tapering article to lay out, and that, therefore, we must use triangulation. Since the center of the stack is directly over the center of the oblong base, the surface is similar on each side of both the horizontal and vertical center lines, therefore it would be necessary to lay out only a quarter pattern, from which plates for the other three quarters of the connection can be lifted.

Divide one-quarter of the circle, which represents the plan view of the round end of the stack, into any number of equal parts. In this case five have been taken and the points of division have been numbered 1, 2, 3, 4, 5 and 6. Also divide one-half of the semi-circle, which forms the corresponding part of the circular end of the oblong base, into the same number of equal parts. In the figure these have been numbered 7, 8, 9, 10, 11 and 12. Project all these points to the corresponding lines in the elevation, the same points having been indicated by the same numbers in the elevation. Now divide the quarter surface into triangles by connecting these points with straight lines as follows: 1 to 8, 8 to 2, 2 to 9, 9 to 3, 3 to 10, 10 to 4, 4 to 11, 11 to 5, 5 to 12 and 12 to 6. Half of these lines have been drawn dotted and half solid so that they may more clearly be distinguished in the pattern. The lines shown in both the plan and the elevation do not show the true length of these lines. The lines are fore-shortened in both of these views. However, we can, by drawing right angle triangles (the height of which is the height of these various lines as shown in the elevation, and the base, the length of the lines as shown in plan), find the true length of the lines by drawing the hypotenuses of these triangles. This work is shown in Fig. 2 where the dotted and solid lines are separated for the sake of clearness.

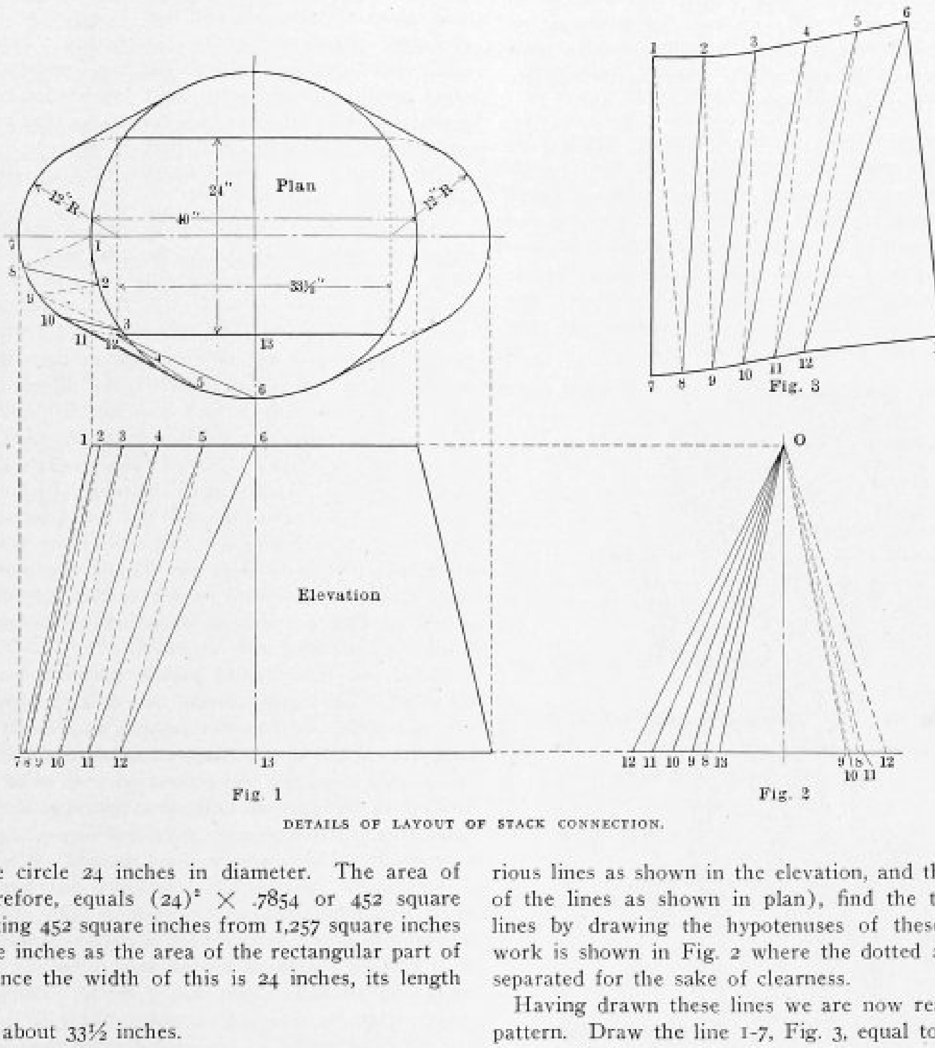


Fig. 1 Fig. 2

DETAILS OF LAYOUT OF STACK CONNECTION.

Having drawn these lines we are now ready to lay out the pattern. Draw the line 1-7, Fig. 3, equal to the length of the line 1-7 in the elevation, Fig. 1. From 7 as a center, with the dividers set to the distance 7-8 in the plan, Fig. 1, draw an arc through the point 8, Fig. 3. With 1 as a center, Fig. 3, and with the trams set to the length of the dotted line o-8, Fig. 2, draw an arc intersecting the one previously drawn, locating the point 8, Fig. 3. Continuing this process, drawing the triangles in their proper places, giving each side of the triangles its true length, the pattern shown in Fig. 3 can be completed. In this pattern no allowances have been made for laps, seams or stretch of the material when rolled to shape.

Q.—1. When are double and single riveted seams used in Scotch boilers?

Q.—2. What kind of riveted seam is the strongest?

Q.—3. What is the formula for finding the thickness of shell plates, given the following conditions: Scotch boiler 15 feet diameter, steam pressure 150 pounds, efficiency of seams 80 percent, factor of safety 4.5, tensile strength of plate 60,000 pounds per square inch?

Q.—4. In a certain Scotch boiler the main stays were originally 2½ inches diameter, and the steam pressure was 160 pounds. If after a time the stays are worn away till their diameter is only 2¼ inches, what pressure would be allowed on the boiler?

Q.—5. What kind of material is allowed for boiler tubes?

A. (1)—Single and double riveted seams are seldom used in Scotch boilers, except for the girth seams. On account of the large diameter and high steam pressure used in the Scotch boiler, it is highly important that the longitudinal seam of the shell shall be as strong as possible. A single or double riveted lap joint rarely has more than 50 or 60 percent of the strength of the plates which it joins. Therefore, since other forms of joints can be made which will give 80 or 90 percent strength, it is obvious that the single or double riveted seam will not be used.

It can be used, however, for the girth seam in a boiler, because the stress in the shell in a longitudinal direction, due to the internal steam pressure, is only one-half the stress set up in the shell in a circumferential direction. Therefore, a joint which has a little more than one-half the strength of the plate is sufficiently strong for the girth seam.

A. (2)—The strongest form of riveted seam which it is practical to use is the quadruple butt joint. That is, a seam with inside and outside cover straps with four rows of rivets on each side of the joint, or eight rows in all. This joint can be made about 93 percent as strong as the plates which it joins. This does not mean that a stronger joint cannot be designed; for it could by using a greater number of rows of rivets; but it would not be practical on account of the expense, the time taken to do the work and the rigidity of the joint.

A. (3)—A formula for finding the thickness of shell plate in any steam boiler shell is

$$t = \frac{D \times P \times F}{2 \times T \times E}$$

where t = thickness of plate in inches.

D = mean diameter of the boiler in inches.

P = the working pressure in pounds per square inch.

F = factor of safety.

T = tensile strength of shell plate in pounds per square inch.

E = percentage strength of the longitudinal seam.

Substituting the figures given in Q. 3 we find the value for t, thickness of the plate in this particular case, to be

$$t = \frac{15 \times 12 \times 150 \times 4.5}{2 \times .80 \times 60{,}000} = 1.2656 \text{ inches.}$$

A. (4)—In order to find the steam pressure which may be allowed on a boiler after the main stays have been reduced by corrosion from 2½ inches to 2¼ inches in diameter, it will be necessary to find the ratio between the strength of stays of these diameters. The ratio of the strength of a stay bar 2¼ inches in diameter to that of a stay bar 2½ inches in diameter is equal to the ratio of the squares of the diameters; that is,

$$\frac{(2.25)^2}{(2.5)^2} = .809.$$

Therefore, the stay after it has been reduced to 2¼ inches in diameter, is only 81 percent as strong as the original stay 2½ inches in diameter. If the strength of the stay has been reduced 81 percent the steam pressure must be reduced a corresponding amount. Therefore, the steam pressure will be $160 \times .81 = 129.6$ pounds per square inch.

A. (5)—For boiler purposes there are five different kinds of tubes, nickel steel, hot-drawn steel, cold-drawn steel, lap-welded steel and lap-welded charcoal iron.

Nickel-steel tube is hardly worth discussing for many reasons. It is at once barred from common use by its extremely high price; it has not passed the experimental stage, and the output is not uniform in quality; acid tests show that it is attacked in spots, and while the actual loss of metal is not great, yet the pits would soon eat through and destroy the tube. An actual test of nickel-steel tubes made by persons who are prejudiced in their favor showed that the tubes cracked transversely just outside the tube sheets, while another make of tubes in the same boiler showed no signs of deterioration.

A cold-drawn steel tube is in many ways very much superior to other makes of tube, but it does not hold first place undisputed. It has a fine finish and a uniform structure, which are the result of its method of manufacture. It is of necessity made from high-grade material, for it would not stand the process of manufacture if it were not. Acid tests show that it is attacked uniformly and that it is not as liable to pitting as a tube of less uniformity of structure. This make of tube withstands bending, belling, beading, longitudinal or transverse crushing much better than any welded tube. The cold-drawn seamless tube has two drawbacks that are very serious, one being the extreme brittleness of the tube as it comes from the drawing bench, which brittleness may not be completely removed by annealing.

Tubes that have not been sufficiently annealed are often the cause of cracks and leaks at the tube seat. The other drawback is caused by the tube being too soft or thoroughly annealed. A deposit of scale will frequently cause blisters or bags in the tube, and if the latter be cold drawn and well annealed, the blister will be much larger than if the tube were harder. The soft metal stretches and allows the diameter to increase considerably before opening, while the harder tube will open up before much stretch takes place. Anyone who has tried to remove a blistered tube through a tube hole 1/32 inch greater in diameter than the original tube will appreciate this point. The hard tube will not last long when it starts to blister, but the soft tube will cost much more in time and money to remove it when it does go. The strong point for the cold-drawn tube is that it does not contain the uncertainty of a weld, but it has a serious drawback in the possibility of insufficient annealing.

Hot-drawn tube should possess most all the advantages of the cold drawn, and has the added advantage that it would not be brittle. It does not possess as smooth a finish as the cold drawn and is not likely to be as accurate to gage. The lap-welded steel tube had proved on tests to be the best on the market at the present time, if everything is taken into consideration. It is best as to price and superior to all the others in strength. The analysis of its material shows it to be hard and somewhat brittle, but practically this hardness does not affect expanding, belling or beading. The charcoal-iron tube has long held first place, but it is only a question of time until it is entirely displaced by the steel tube. It cannot compete in price, and tests show that it cannot compare in strength, even though it shows a superior chemical composition. On test all good grades of lap-welded tubes show that the weld is the strongest part of the tube, but the possibility of a defect still exists.

The following series of tests were made to determine the best tube for boiler purposes. Tests were made on four different makes of charcoal iron, one made of lap-welded steel and one of cold-drawn steel. All the tubes tested were 4 inches in diameter and No. 10 gage, and from each make, purchased in the open market, six specimens were taken, each 24 inches long. These pieces were subjected to cold water pressure in such a way that they were restrained from expanding for a distance of about 1½ inches at each end, but free to expand throughout the remainder of their length. The breaking pressures given in the table are the pressures in pounds per square inch at which the specimen burst. Samples of each make were tested on the testing machine and analyzed chemically. The results of these tests are included in the table.

Six specimens of each make, 2 inches long, were crushed under a hydraulic press in the direction of the axis of the tube and the figures at the bottom of the table give the results relatively. Cold-drawn steel showed no signs of cracking in any of the specimens and is number 1, the other numbers show the order in which the other makes follow. Number 2 means that it was the second best tube subjected to crushing, and not that it had twice as many defects.

The table does not tell at a glance which tube would be the best, but it gives considerable information, which, coupled with the practical working of the tubes, tells which is best. The tubes must be tested for expanding, belling and beading and must be examined for smoothness, straightness and variation from gage and diameter. Tests for corrosion have not proven very satisfactory on account of the variation from the actual conditions and the lack of uniformity of results. Many claim that the lap-welded steel tube is the best on the market at the present time, even though some may think it too hard. A tube should be as hard as the process of expanding, belling or beading will permit.

PHYSICAL AND CHEMICAL PROPERTIES OF BOILER TUBES.

Physical and Chemical Properties.	Seamless Cold Drawn Steel.	Lap Welded Steel.	Charcoal Iron (T).	Charcoal Iron (W).	Charcoal Iron (S).	Charcoal Iron (R).
Carbon	0.1867	0.0933	0.068	(Trace un	der 0.06)	Trace.
Manganese	0.4233	0.3133	0.238	(Trace un	der 0.06)	Trace.
Phosphorus	0.0103	0.105	0.029	0.048	0.092	0.054
Sulphur	0.0313	0.072	0.027	0.019	0.0153	0.0147
Silicon	0.07	0.010	0.032	0.03	0.087	0.0173
Tensile strength	51,385	57,495	50,357	47,260	47,163	46,993
Elastic limit	29,928	34,850	32,180	30,830	27,800	30,507
Elongation	21.5%	16.7%	22.2%	20.7%	15.6%	13.3%
Reduction of area	51.3%	45.6%	53.6%	45.9%	33.1%	37.1%
Back pressure, lbs.	4.183	4.733	3.970	3.700	3.333	3.000
Crushing	1	3	2	2	5	4

EDITOR'S NOTE:—In the March, 1908, issue of THE BOILER MAKER a correspondent asked the question, "How do you find the working pressure of a boiler?" The answer given was the formula prescribed by the Rules and Regulations of the Board of Supervising Inspectors of the United States Steamboat Inspection Service. It was not stated, however, in the answer that this was the United States marine rule, and so in order that no one may be misled this occasion is taken to call attention to the fact.

While our correspondent was a marine engineer, and wished to know how to figure the working pressure of a marine boiler as prescribed by the United States rule, this was not stated in the question, and therefore one might be led to think that the rule given was a general one, which should be applied to all boilers, when, as a matter of fact, it should be applied only to those boilers built for use in the navigable waters of the United States. This rule is not a good one for finding working pressure of a boiler or for finding the thickness of shell plate for a boiler for a certain pressure. Although it has been prescribed by the United States Steamboat Inspectors for a long time, yet it has been condemned by nearly all writers on the subject of the strength of steam boilers as well as all boiler manufacturers, inspectors, etc. The worst feature of this rule is that it does not take into account the strength of the riveted joint in the boiler shell, except to allow 20 percent additional pressure where the longitudinal joint of the boiler is double riveted. As far as the rule is concerned there is nothing to be gained by using a stronger joint than a double riveted lap seam.

A general rule which may be applied to any boiler for finding the safe working pressure is as follows:

$$P = \frac{T \times t \times E}{\frac{1}{2} D \times F}$$

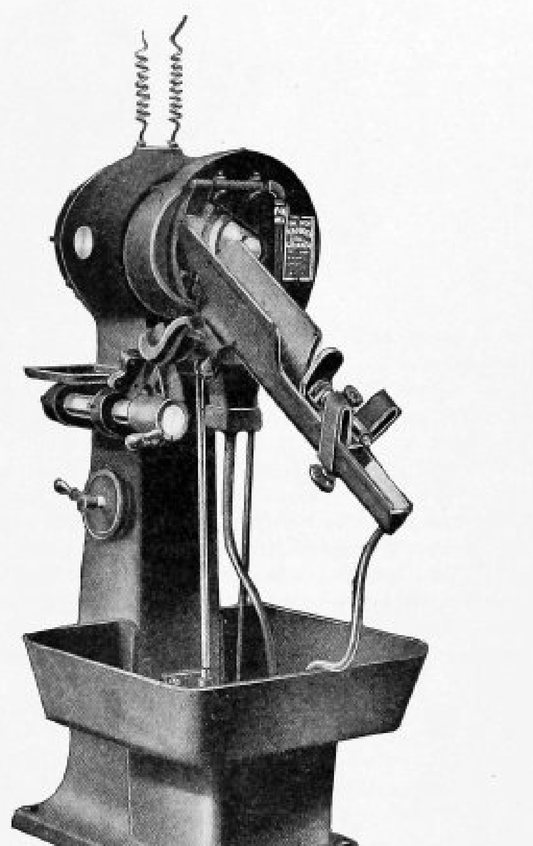
P = safe working pressure in pounds per square inch.
T = tensile strength in pounds per square inch.
t = thickness of plate in inches.
D = inside diameter of boiler in inches.
F = factor of safety.

The only chance for error in this rule is the possibility that an improper factor of safety may be used to suit certain conditions.

ENGINEERING SPECIALTIES.

The Yankee Drill Grinder.

No matter how satisfactory the drilling machine may be or what its type, it can never do good work without good drills. No matter how superior the steel and how fine the temper, the drill can never do good work unless it is correctly ground. It is passing strange that some people, not as many now as formerly, take so much pains to see that the drilling machine is first class, and even that high-grade drills are furnished, and



then nullify all the results of their pains by the necessarily inaccurate hand grinding of the drills.

When only the old style drill grinders were on the market there was some excuse for this condition, as even some bright mechanics and business men felt that the time-consuming adjustments, necessary before the drill could be ground, cost more than the advantages were worth. Since the advent of the new Yankee drill grinder, made by the Wilmarth & Morman Company, Grand Rapids, Mich., this position is untenable, as the preparations for accurate grinding are practically reduced to laying the drill in the holder. Of course, the tail stock in the holder must be set up to accommodate the length of drill to be ground, provided this is not in about the right position and the liprest has to be slipped up with the left hand at the same time the drill is laid in with the right. It is claimed that two to five seconds is ample time in which to prepare to grind any ordinary drill on the new Yankee drill grinder, and when the machine is ready it will grind faster than can be done by hand, to say nothing of doing it just right, rather than "good enough to answer."

In grinding a drill just right a large number of separate problems are involved, and it is not strange that in the past drill-grinding machines have been complicated pieces of mechanism. For instance, a preliminary to grinding on the old style machines was the calipering of the drill between gage jaws as a means of regulating the position of the holder. This calipering called for several bothersome adjustments.

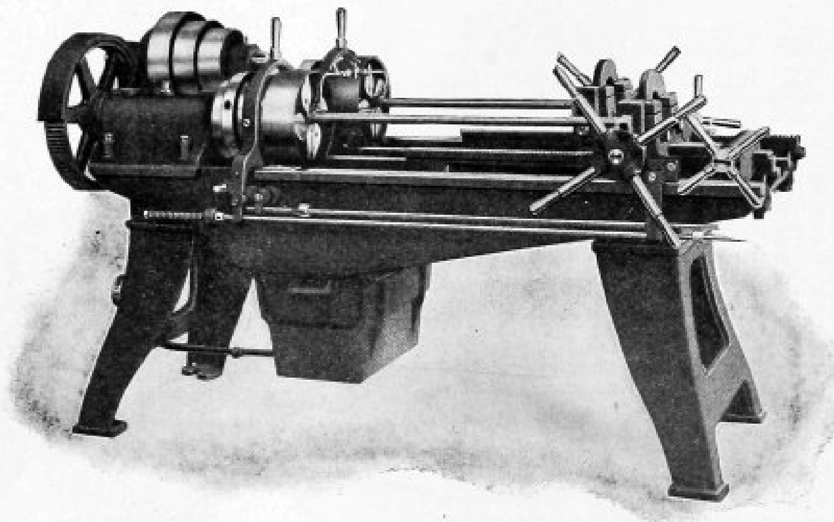
Among the requisites for a perfect working drill aside from good steel and the right temper are the following: 1. It must be sharp. 2. Its point must be in the center of the drill. 3. It must have the proper degree of angle for both the cutting lips (59 degrees standard), and each lip must do its share of the cutting. 4. It must have clearance and the right clearance for the particular work in hand, and it must have a gradual increase from periphery to center. The construction of the new Yankee drill grinder is designed to provide all these advantages practically without attention on the part of the operator.

The result of its use is that drills produce holes of the same size as the drills (almost an impossibility with hand-ground drills). The drills stay sharp longer, break less frequently and stand harder working conditions and work faster. Beside that they enable more rapid grinding than it is possible by hand. It takes a skilled mechanic to grind a drill "good enough" by hand, while a bright boy can grind them "just right" with the new Yankee drill grinder.

The new Yankee drill grinder comprises something over fifty styles, sizes and combinations ranging from small bench machines designed for drills of from no. 60 to 5/8 inch up to large, heavy wet grinding machines suited for drills of from 1 inch to 5 inches. The intermediate sizes include drill grinders in combination with cutter and reamer grinders, surface grinders, swing grinders, tool grinders, etc. Machines are made either for wet or dry grinding, but the growth in popularity of the wet grinders is very noticeable. The wet machines can be used dry when desired, which adds to their advantage. The motor-driven machines are not only mechanically correct in construction, but are also symmetrical and pleasing in appearance. The motor is direct connected in its true sense, as the armature shaft and wheel spindle are one and the same.

Landis Staybolt Cutter.

The Landis Machine Company, Waynesboro, Pa., has recently placed on the market a new staybolt cutter. This machine is constructed on the same general principle as all other Landis bolt-threading machines, but on a different principle from almost any other type of staybolt machine. No lead screw is used to govern the pitch of the rod which is being threaded. The chasers, of which there are four in each head, are so designed that the front, or working teeth, will do the cutting at all times, while the back teeth can do no cutting at all, but extend across the cutting line, forming a lead nut which bears on the threaded rod and draws it into the cutting teeth true to the pitch of the die. This gives a lead so positive that it is claimed to be impossible to alter the pitch of the thread by retarding or forcing the rod into the die. The chasers are each 4 inches long, and have threads milled on the flat side, running the full length of the chasers. The chasers are set tangent to the rod, which is being threaded, and thus give the correct cutting clearance. The rake can be ground to any angle desired to suit the kind of material being cut, and a rolling chip can be taken, as with a lathe tool, consequently the highest possible speed in thread cutting can be employed. All the chasers are exactly alike, and, therefore, interchangeable. The chasers are not hobbed, but are milled, and the die never requires to be annealed, hobbed or retempered, consequently there is no liability of destroying the accuracy of the die.



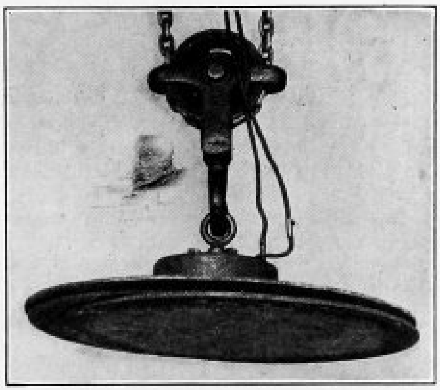
The machine is built in either single or double head patterns in sizes up to 1½-inch capacity. The carriage has an adjustment up and down and sidewise, so that the work can be centered to the die and the cutting strain removed. Each machine is provided with a pump, countershaft, wrenches and an automatic throw-out. The main spindles are so arranged that any oil which may be carried into the spindle will feed back into the oil tank.

Lifting Magnets.

A device has recently come into use by which it is intended to overcome some of the difficulties of fastening plates, bars or heavy weights to cranes and other forms of lifting apparatus. This device is known as a lifting magnet, and comprises essentially a small casting, either of iron or steel, hollowed on the inside to receive an electro-magnet. The particular magnet illustrated was designed by the Cutler-Hammer Clutch Company, Milwaukee, Wis., for lifting plates or bars. The magnet is capable of picking up several plates at a time, piled one above the other, and then by gradually decreasing the strength of the current in the magnetic coil any desired number of plates can be dropped from the magnet at a time.

The magnet is hung directly on the crane hook, and its operation is very simple. It is merely necessary to lower the magnet upon the plate, bar, or whatever piece of material is to be lifted, switch on the current, thus energizing the magnet, raise the load and carry it to any desired point, lower it, and then it may be released simply by turning off the current from the magnet. Of course it must be understood that the lifting magnet is only a device for holding the load on the crane, and helps in no way to lift the load—other means must be provided for this.

The Cutler-Hammer Clutch Company manufacture these lifting magnets in various sizes and designs, depending on the purposes for which they are to be used. The most common



design is a circular magnet, corrugated on the outside to produce as large a surface as possible for radiating heat, and provided with a circular aperture cored clear through the center of the magnet body, so that a flue is formed for the circulation of air through the magnet. This type of magnet is found especially useful for handling scrap, pig iron and other small pieces of metal.

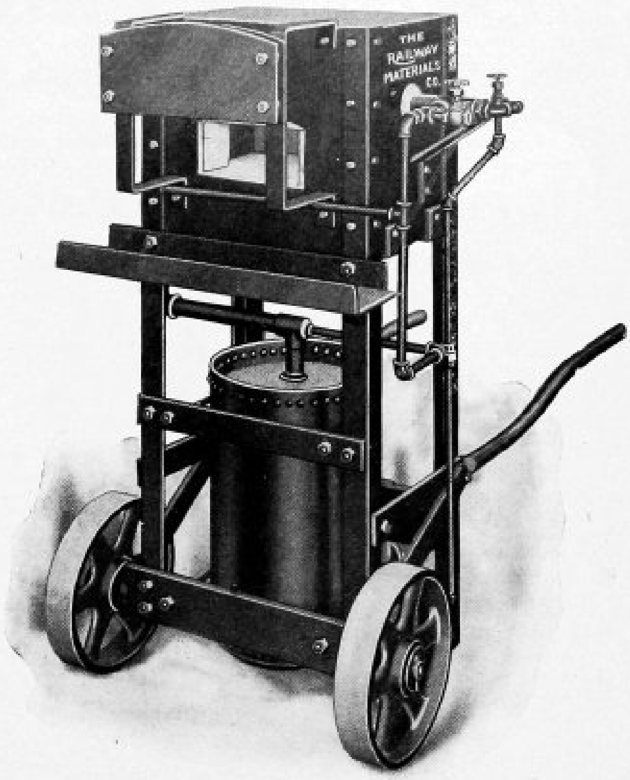
Portable Oil Rivet Furnace.

To meet the demand for a furnace which is able to keep a gang of riveters busy and at the same time be of such construction that it can readily be moved about, the Railway Materials Company, of New York, has recently placed on the market a new portable oil rivet furnace. The furnace is mounted upon three wheels—two of which are plainly visible in the cut. The third wheel is smaller and is mounted in a swivelled truck. Two handles are provided which are arranged in such manner that the furnace can be handled about in a similar fashion to an ordinary truck. In the trucking position the handles are raised slightly by the operator, and the whole furnace then becomes balanced upon the axle. The furnace, bricked up and with the 10-gallon supply tank full of oil, weighs approximately 550 pounds.

The furnace dimensions are such that in renewing the lining, standard shapes of brick can be used throughout, the width, length and height being such that any standard fire-brick will fit into place without chipping. This renders it unnecessary to carry special tiles in stock. The furnace plates do not need to be taken down to rebrick, as the top is purposely left open to permit of ready renewal.

Provision is made to protect the operator from the heat, and deflector plates are arranged across the front of the furnace to provide for the comfort of the operator. The door height is arranged with the view of accessibility.

The burner is especially designed for economy in both air and oil, and is so arranged that practically no noise results from combustion. This latter feature has been carefully provided for, and this difficulty—so annoyingly characteristic of



high-pressure burners—has been overcome. The burner is intended to operate with compressed air, and any normal pressure above 10 pounds per square inch is sufficient for good results. The piping is so arranged that if the compressed air supply is cut off the flow of oil to the burner automatically ceases, and the oil in the pipes drains to the supply tank.

It is claimed that the furnace will readily heat rivets for two air hammers and can be ready for operation in five minutes after it is lighted up. Moreover, it is designed to take up the smallest possible floor space and will readily find a footing—even on such crowded places as the top of a locomotive tender tank, where the rivet boy is accessible to the "man inside."

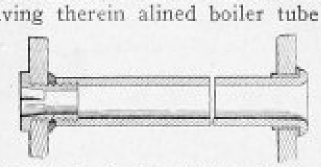
SELECTED BOILER PATENTS.

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.

878,353. BOILER TUBE. Walter Allen Compton, of Columbus, Ohio.

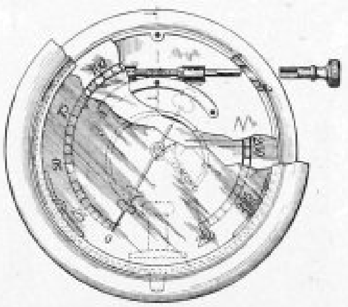
Claim.—The combination with the front and rear tube sheets of a boiler having therein alined boiler tube passages, of a



boiler tube adapted to be inserted through the passage in said front tube sheet, an annular flange on the forward end of said tube to engage the outer side of said tube sheet, a hollow exteriorly threaded bushing adapted to be screwed through the passage in the rear tube sheet and into the threaded rear end of said tube, an annular flange or bead formed on the outer end of said bushing to engage the outer sides of said rear tube sheet, a sleeve or gasket arranged on the forward end of said tube and passing through the aperture in the front tube sheet, and around the flange on said forward end of the tube, and a washer arranged between the rear end of the tube and the adjacent side of the rear tube sheet. Two claims.

873,034. STEAM OR VACUUM GAGE. James Ely, 85 Chambers street, New York.

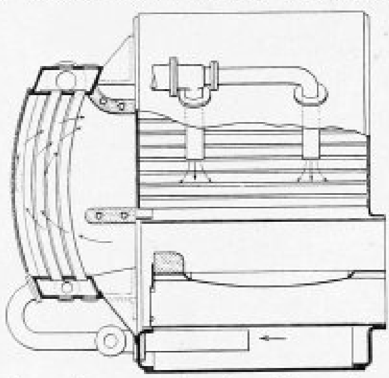
Claim.—In a steam gage, the combination with a casing, a rotatable indicating hand and means for rotating same in the operation of the device, of a rotatably mounted scale carrying



disk, means arranged within the casing for rotatively adjusting same and for locking the disk in its adjusted position, and a removable key by which access may be had to such adjusting means from the exterior of the casing.—Three claims.

876,378. TUBULAR BOILER. Wilhelm Möller, of Hamburg, Germany.

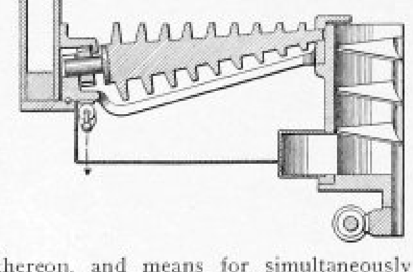
Claim.—A boiler having an upper perforated water chamber above the water level, covers closing said chamber, pipes connecting said chamber with the boiler below the water level,



a lower perforated water chamber below the upper water chamber, covers closing said lower chamber, curved pipes connecting the upper and lower chambers and removable through the chamber perforations, and a feed-water pipe entering the lower chamber. One claim.

877,487. REVOLVING GRATE. Franz Burger, of Fort Wayne, Ind., assignor of three-fourths to Henry M. Williams, of Fort Wayne.

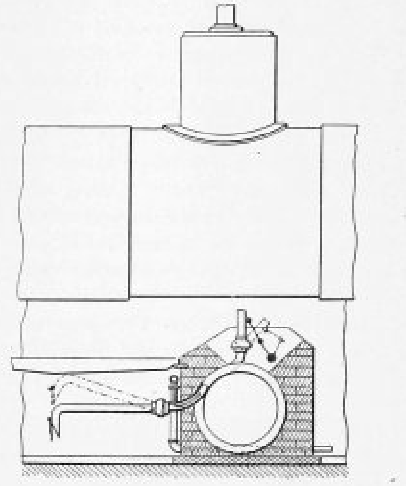
Claim.—The combination with a central fuel feeding tube, of a circular revolving grate, rotating grate-bars mounted



radially thereon, and means for simultaneously and intermittently revolving the grate and rotating the grate-bars step by step. Ten claims.

877,142. MEANS FOR INCREASING AND PROMOTING THE COMBUSTION OF FUEL. George R. Torrey, of Washington, D. C.

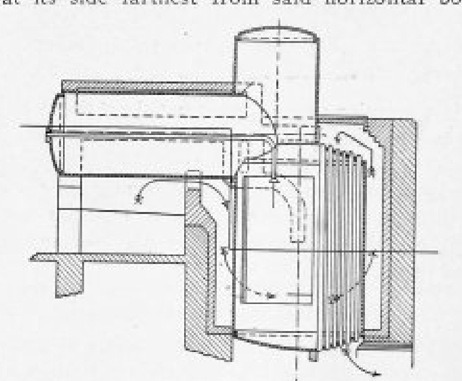
Claim.—In a steam boiler, a furnace, a fire chamber, a bridge wall, a vortex chamber within the bridge wall for giving a



circular, centrifugal action to steam and air, and means for forcing said steam and air into and through the fire chamber of the furnace. Seven claims.

877,334. STEAM GENERATOR. Franz Hecht, of Tegel, Germany.

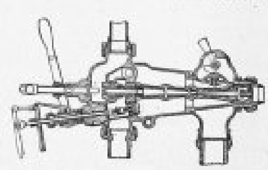
Claim.—In a steam generator, the combination with a horizontal cylindrical boiler, of a fire grate located beneath said horizontal boiler, a vertical tubular boiler arranged adjacent to the end of said horizontal boiler, and having its tubes arranged at its side farthest from said horizontal boiler, and



having an open space extending from end to end in communication with the interior of the horizontal boiler, means for supplying feed water to said open space, a steam dome connecting with said boilers at their adjacent portions, and means for conveying the furnace gases from the grate down one side of said tubular boiler and up the other side for passage downwardly through the tubes of said boiler. Three claims.

880,984. INJECTOR. James M. Gailey, McKeesport, Pa.

Claim.—An injector having a main or water-controlling valve provided with a tubular stem, an auxiliary valve, a rod extending through said tubular stem and turnably connected



with said inlet or auxiliary valve, a hand-operable member connected with said stem for turning the same, a hand-operable member connected with said rod for moving the same in an endwise direction to cause the operation of said auxiliary or inlet valve, and linkage means jointed to the two hand-operable members for causing them to turn together. Seven claims.

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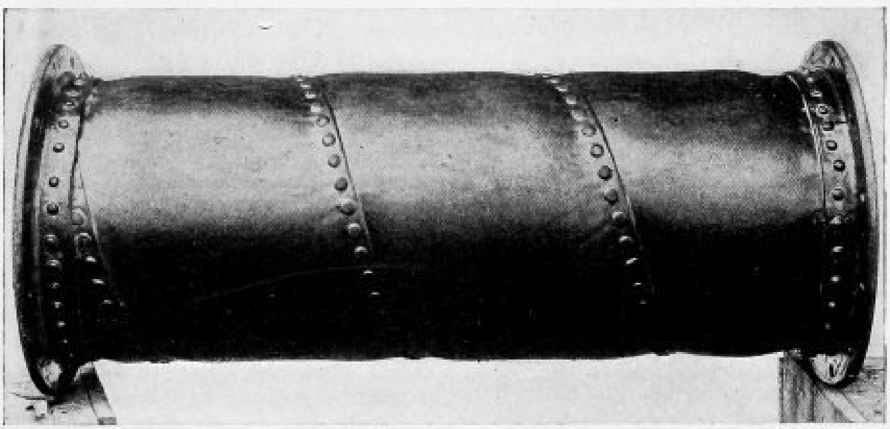
INTERESTING TEST OF SPIRAL RIVETED PIPE.

That a cylindrical pipe or tank can be constructed of metal plates riveted together in such a manner that the seam produces no weakness in the structure is a well-known fact. This is accomplished by using a diagonal seam, the relation between the pitch and diameter of the rivets being somewhat different than is the case in an ordinary riveted joint. The pitch as compared with the diameter is sufficiently large, so that the percentage strength of the section of plate left between the rivet holes is comparatively high; say about 75 percent. The seam is then inclined at as small an angle as is practical from the girth seam, so that the number of rivets in a section of given length, measured along the axis of the cylinder, is sufficient to make the shearing strength of the rivets as great or greater than the strength of the plate.



SECTION OF PIPE AFTER TEST FOR BURSTING PRESSURE.

Taking a specific case where the diagonal riveted seam is used commercially, it is interesting to figure out the exact strength of the joint and see how it stands up under an actual hydraulic test. A section of 12-inch spiral riveted pipe is shown in the photograph which has been tested with a hydraulic pressure of 650 pounds per square inch. The pipe, which is the commercial product of the American Spiral Pipe Works, of Chicago, is made of 16-gage steel of 60,000 pounds tensile strength. The seams are single-riveted lap joints with rivets 15/64 inch in diameter when driven, and spaced about 1 inch apart. The rivets were driven cold. The angle which the seam makes with a section at right angles to the axis of the cylinder, that is, with a girth seam, is 16 degrees, as shown on the line sketch.

The section of pipe shown in the photograph was subjected to a hydraulic pressure of 650 pounds per square inch without bursting. Before the test the inside diameter of the pipe was 12.1 inches and the thickness of the plate .063 inch. After the completion of the test the portion of the pipe between the seams had increased more than ¾ of an inch in diameter, although the diameter at the seams had remained practically constant. The theoretical bursting pressure of 12-inch pipe, built of 16-gage steel of 60,000 pounds tensile strength, is 625 pounds. Therefore, it will be seen that the test pressure was really carried beyond the point at which the pipe might be expected to burst, even if the shell were one solid piece of metal with no seams to weaken it. The pressure of 650 pounds was applied three times, and no signs of leakage or rupture of the seam were visible.

From a practical standpoint this is conclusive proof that the diagonal seam stiffens and strengthens a cylindrical shell subjected to internal pressure. It will now be of interest to see how this figures out theoretically. The conditions of the problem are as follows: Thickness of plate, .063 inch; tensile strength of plate, 60,000 pounds; diameter of rivets, .2343 inch; area of one rivet, .0431 square inch; pitch of rivets, 1 inch; shearing strength of rivets, 45,000 pounds per square inch; angle of inclination of seam, 16 degrees.

The efficiency of the net section of plate in the seam is

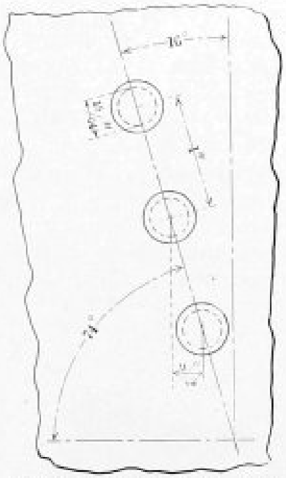
$$\frac{1 - .2343}{1} = 76.57 \text{ percent.}$$

The ratio of the strength of a diagonal joint to that of a longitudinal joint may be found by dividing 2 by the square root of 3 times the square of the cosine of the angle between the longitudinal and diagonal seams, plus 1. The angle which the diagonal seam makes with the girth seam in this problem is 16 degrees. Since the girth seam and the longitudinal seam are at right angles to each other, the angle which the diagonal seam makes with the longitudinal seam will be 90 degrees — 16 degrees, or 74 degrees. Looking in a table of natural sines and cosines we find that the cosine of 74 degrees is .2756. Therefore, substituting this value in the formula, we find that this ratio works out as follows:

$$\frac{2}{\sqrt{3 \times \cos^2 74 + 1}} = \frac{2}{\sqrt{3 \times (.2756)^2 + 1}} = 1.76.$$

Therefore, the diagonal seam is 1.76 times as strong as the longitudinal seam. We found the percentage strength of the joint as ordinarily figured to be 76.57. Multiplying this by 1.76 we find the percentage strength of the diagonal joint is 135; that is, the joint is 1.35 times as strong as the solid shell of the pipe.

Figuring now on the strength of the rivets in the seam we see by referring to the diagram that the pitch in a longitudinal direction is equal to the pitch of rivets along the seam times the sine of the angle, 16 degrees. The pitch is 1 inch and the



DIMENSIONS OF DIAGONAL SEAM.

sine of 16 degrees is .2756. Therefore the pitch of rivets, as measured in a longitudinal direction or in the direction of the axis of the pipe, is .2756 inch, or about 9/32 inch. The strength of a solid section of plate for this pitch is 60,000 × .2756 × .063 = 1,042 pounds. The strength of the rivets for one pitch is .0431 × 45,000 = 1,940 pounds. $\frac{1{,}940 \times 100}{1{,}042} =$ 186 percent. Therefore, the strength of the rivets in the seam is 1.86 times as great as the solid plate.

From the above calculations it is easy to see why cylindrical pipe built with a spiral seam is really stiffer and stronger than when there is no joint whatever in the pipe. It has been shown that the riveted joints are at least 135 percent as strong as the solid pipe in this particular case, and that the pipe can actually stand a hydraulic pressure slightly in excess of the theoretical bursting pressure without leaking or failing in any way.

Formulae for Weight of Riveted Steel Pipe

BY D. M. M'LEAN.

In estimating on riveted steel pipe, flumes, penstocks, and circular tanks, considerable time may be saved, and at the same time results secured which are usually accurate enough for all practical purposes, by the use of formulas such as the following:

$$W = .33\tfrac{1}{3}\ dw. \qquad (1)$$

Where W = weight per foot of run of tube in pounds.

d = diameter of tube in inches.

w = weight of plate per square foot in pounds.

In other words, one-third of the result obtained by multiplying the diameter of the tube in inches by the weight in pounds per square foot of the material used, is the average weight per foot of run of the pipe or tube.

This rule is easy to remember, but gives results which are rather too heavy to be always desirable.

$$W = .25\ dw \times 1.125 \qquad (2)$$

Rule No. 2 is really equivalent to taking one-fourth of the result obtained by multiplying the diameter of the tube by the weight per square foot of the material used and adding to this one-eighth of itself. The formula is really $W = .28125\ dw.$, but it is easier to remember and use the formula expressed in words, as above.

The following formula was devised by the writer for his own use, and has proved the most satisfactory of all rules for this purpose.

$$W = (dw \times .30) \times .95 \qquad (3)$$

Expressed in words, this is as follows:

Take dw as above and allow a discount of 70 and five percent off. For example, take a tube 40 inches diameter of ¼-inch plate.

40 inches × 11.23 =	449.20
To deduct 70 percent, multiply by	.30
	134.7600
Deduct 5 percent,	6.738
Answer,	128.022 pounds per lineal foot of tube.

The formula really is $W = .285\ dw$, but treating it after the manner of a trade discount, it may easily be remembered and often worked mentally.

It will be understood that these formulas can only be used on the general run of double-riveted lap-joint work, and for this they give good results on anything from 18 inches to 20 feet in diameter. For high-pressure work requiring triple-riveted butt-strap joints special estimates will be necessary. Otherwise the weights obtained by the last rule, check pretty closely with those obtained by estimating on the actual plates and rivets to be provided for the work.

As a general rule we have found that the published tables of weights of riveted steel pipe run too light and are frequently misleading. The writer has always found it best to err slightly on the heavy side, therefore he always adds the full manufacturer's allowance for overweight given in the steel companies' books for plates up to 75 inches in width.

The following table gives the theoretical weights and the adjusted weights (so-called) for the usual thicknesses of steel plates in common use. These corrected or adjusted weights are the weights used in the above formulas:

Thickness.	Theoretical Weight.	Adjusted Weight.
3/16	7.65	8.42
1/4	10.207	11.23
5/16	12.75	13.78
3/8	15.31	16.38
7/16	17.86	18.93
1/2	20.41	21.44
9/16	22.96	24.00
5/8	25.51	26.50
11/16	28.07	29.20
3/4	30.62	30.80
13/16	33.17	34.50

By covering the boiler setting with a layer of asbestos cement, passing over this a canvas, and painting the whole with a heavy coat, an American engineer has, it is said, been able to effect a saving of about 12.5 percent of his coal bill. It is stated that thoroughly coating the brickwork with red paint so as to fill the pores will cause a considerable saving of fuel in almost any boiler.

German Methods of Marine Boiler Construction.*

BY PROF. WALTER MENTZ.

This article describes the German methods of building marine boilers, in so far as the machinery used and the actual shop operations are concerned. In the rolling mills, boiler plates are cut to size with large shears, a process which harms the fibers of the material in the immediate vicinity of the cut, and which makes the metal unfit for the construction of a good, solid riveted joint. For this reason, and because the edges of the plate which come together must be made somewhat oblique, the plates are first planed to their exact dimensions. Moreover, it is a good plan to measure the outside diameter of the courses and to determine the circumference of the boiler shell plates for both inside and outside courses corresponding to the mean diameter, since the diameter of the courses seldom proves to be exactly in accordance with the drawing. The mean diameter of the finished courses must correspond substantially with that computed from the length of the shell plates when rolled out flat.

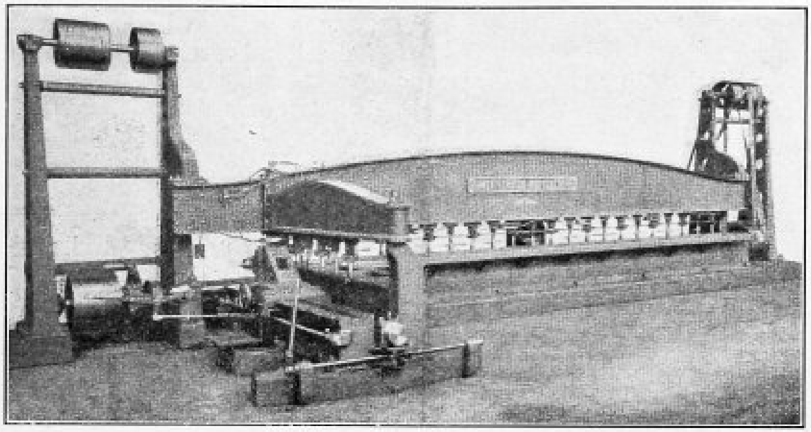


FIG. 1.—PLATE-EDGE PLANER.

Fig. 1 shows one of the plate-edge planing machines built by the firm of Ernest Schiess, in Düsseldorf. Frequently the cross arm, which can be seen in the foreground at the left-hand side of the figure, is omitted, so that in place of two tool beds, arranged at right angles to each other, only one tool bed is furnished, and in that case each plate must be changed about four times in order to plane all the edges. On the other hand, when the cross arm is supplied, the plate can be planed in two directions at the same time, so that there is an appreciable saving in time.

The machine illustrated is capable of planing plates 394 inches long and 98 inches wide. If the plates are longer their position must be shifted once in the direction of their length. If the usual method of doing the work is followed, a small portion of the plate (marked "*a*" in Fig. 2) is allowed to project beyond the travel of the tool, which, later on, will be either thinned down or cut out for the joining of the longitudinal seam. Two notches, *b* and *c*, must be cut with a chisel in the edges which are adjacent to the girth seams, so that the tool can have a chance to begin its cut, and also run over at the end of the cut. If the planer is large enough, the cut will run through from *b* to *c*, but if not, another notch *d* must be made. The cut will then be taken first from *b* to *d*; then, after the position of the plate has been changed, from *d* to *c*.

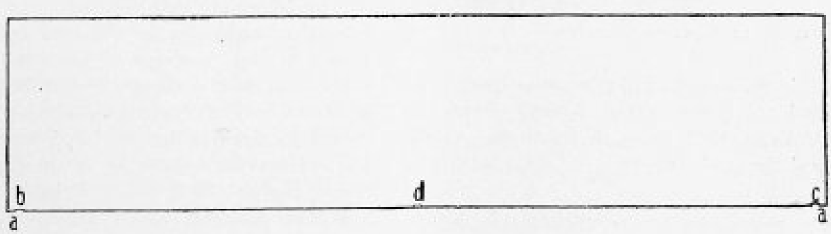


FIG. 2.

The plate is fastened to the bed of the machine either by screw jacks, operated by hand, or, as shown in Fig. 1, by hydraulic jacks. The movable carriage on which the tool is placed is driven by a long lead screw, its travel being controlled by means of adjustable dogs or stops. The tool rest on the carriage can be turned through an angle of 180 degrees on its horizontal axis, so that with a symmetrically-ground tool cuts can be taken on both the forward and backward travel of the carriage, thus shortening the time of planing by one-half. The highest cutting speed is about 7.1 inches per second.

After the shell plates are planed exactly to size they are either rolled into a circular shape or pressed hydraulically. Plate bending machines with rolls are seldom found. They consist, as shown in Fig. 3, of an upper roll (working roll) movable in a vertical direction, and two lower rolls (bending rolls). Since a plate which lies horizontally in the rolls is liable to be spoilt during the rolling, because of the weight of the part of the plate which has been freed from the rolls, this type of machine is frequently installed with the rolls, placed vertically. In order to prevent the rolls themselves from bending, due to their great length, they are often supported by one or two intermediate rolls, uniformly distributed along their length, as shown dotted in Fig. 3. Only the two smaller bending rolls are supplied with power, and this is done by means of gears, while the whole machine is driven either by open and crossed belts or by a reversible electric motor.

*From *Schiffbau*.

In order to remove a plate from the rolls after it has been rolled to a circular shape in one piece, either the upper roll must be sufficiently light to be removed, or the upper end of one of the housings must be hinged, so that it can be turned

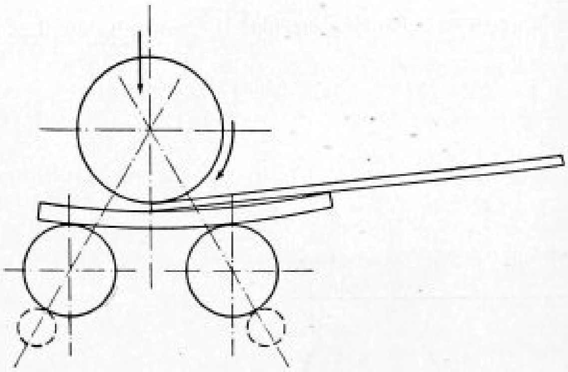


FIG. 3.

to one side. If a thin plate is being rolled, by rolling back and forth the first 5 or 6 feet of the plate, and measuring it with a template until the upper roll is adjusted properly to give the plate the exact curvature, then the remaining part of the plate can be rolled with only one pass through the machine.

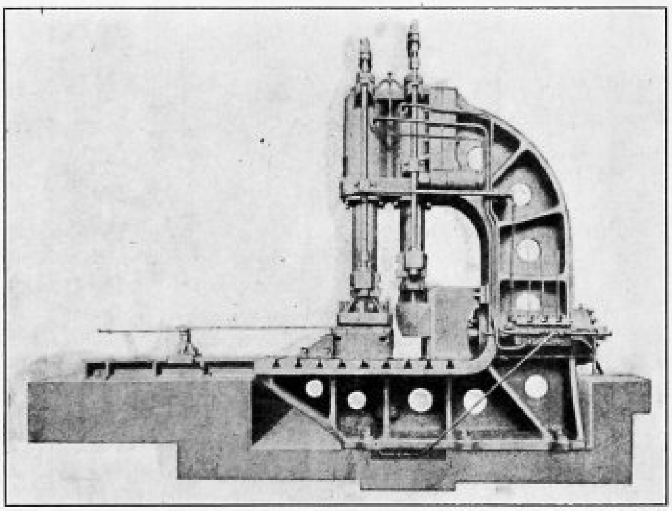


FIG. 4.—HYDRAULIC FLANGING MACHINE.

With thicker plates it is seldom that the machine has sufficient strength to bend the plate to the desired shape by passing it through the rolls once. It must, therefote, be passed through the rolls several times, the upper roll being set down a slight amount for each pass.

Difficulty is found in bending plates with bending rolls when it comes to bending the ends of the plate, which are naturally not wide enough to fit the rolls. There is one simple way in which this may be done: Lay a heavy piece of plate, which has been bent to correspond to the desired radius in the rolls, as shown in Fig. 3, and let this run through the machine with the first and last part of the shell plate, until these parts have received the desired curvature. The same result may be accomplished by pressing the plate on the hydraulic riveting machine to fit a template, or by hammering it by hand, a method which is much less to be recommended on account of the damage to the plate.

The type of machine which is more commonly used for bending shell plates is a hydraulic bending press, in which the laps can be bent as easily as any other part of the plate. Fig. 8 shows a machine of this type built by the firm of Haniel & Lueg, of Düsseldorf.

Between the two outside parabola shaped supports, or standards, is located a press beam, which is mounted on rollers and furnished with a guide at the top. Between this press beam and the right-hand support or housing is a hydraulic pressure cylinder, the plunger of which, by its upward motion, exerts a pressure on the guides through four steel rollers, and thereby presses the beam against the left-hand support or housing.

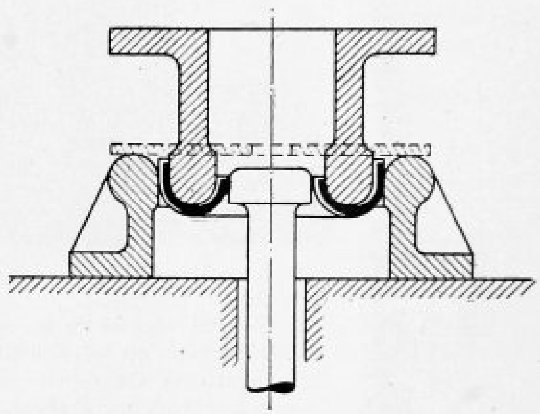


FIG. 7.

Of the surfaces of the left-hand support and of the press beam, which face each other, one is convex and the other concave, both of the same radius. Therefore, if a boiler plate is placed between them and the press bar forced by the hydraulic cylinder to the left, such a distance that only the thickness of the plate is left between it and the left-hand support, the plate will be pressed to this radius.

Smaller radij can be obtained by placing in the press, as shown in Fig. 5, strips of plate with curved edges. Curvatures of greater radii can be obtained by allowing the plunger to travel only a short distance, so that the press beam is not forced up against the left-hand support, forcing the plate to a curvature corresponding to the position of the points *a*, *b* and *c*, Fig. 6. If it is not desired to regulate the lift of the hydraulic plunger, which may be carefully controlled, less curvature can be obtained by using a strip of plate, as shown in black, Fig. 6. In this way, however, a rough surface is

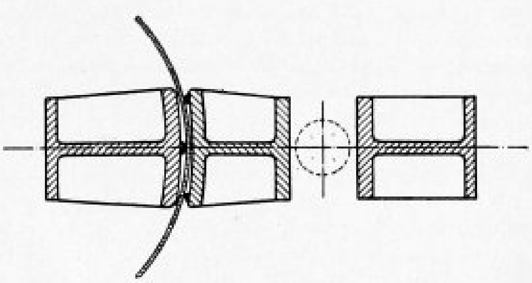


FIG. 5.

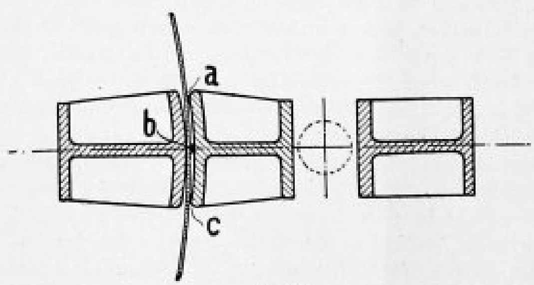


FIG. 6.

obtained with no smooth curvature. The finished plate has the form of a polygon, since the pressure is not distributed uniformly over the plate, but is concentrated at isolated points. This variation from the true circular shape is, however, so unimportant that it can practically be neglected. If it is desired always to obtain an exact circular form for the plate, the convex and concave surfaces between which the plate is pressed can be provided with interchangeable castings with faces of the desired radii, so that after their insertion the plunger of the hydraulic cylinder can always make a complete stroke to give the required curvature to the plate.

The return stroke of the press beam is accomplished, after the plunger has been allowed to drop again into the hydraulic cylinder, by means of a piston working in a small horizontal cylinder. By means of an hydraulically-operated block and tackle the plate may be simultaneously given an automatic feed, the amount of the feed being regulated at the will of the operator. A cylindrical plate which has been rolled in one piece can be lifted out of the machine by raising the rectangular bar which joins the two outside housings at the top. This is swung upwards by means of a small hydraulic cylinder, located on the upper right-hand part of the machine, which transmits its motion through a chain and lever. The available height of this machine, which can be used for bending, is 138 inches, and the pressure exerted is 565 tons. English-built bending machines frequently have in place of the oblique surfaces, on which the two pairs of rollers work, an arrangement of levers to give the motion to the press beam.

The flanging of the plates which form the boiler heads and the tube and back sheets of the combustion chambers is done in small shops by hand by hammering down the edges over a cast-iron matrix. Since it is necessary to do this hammering in about four operations, the plate must be heated a small portion at a time at least several times; which, beside the excessive consumption of fuel, has the disadvantage that the plate is injured through the repeated heating and cooling, in spite of the fact of the subsequent annealing of the whole piece.

In large shops a flanging machine is commonly found of the type shown in Fig. 4. Besides two vertical hydraulic cylinders there is also a horizontal cylinder, which can be seen on the right-hand side of the illustration. The plate to be flanged is heated for the greater part of its circumference, and eventually is placed on the bed or support shown at the left of the figure; then it is held fast on the matrix by the left-hand vertical plunger, while a specially-formed die, fastened to the right-hand vertical plunger, gradually presses down the edge around the matrix. After the second plunger has been raised the first plunger is also raised, the plate slightly turned around and the operation repeated. Since the flanged edge is not left entirely smooth but somewhat crimped or curled, instead of further work with the vertical cylinders, the horizontal cylinder is brought into action, which, by means of a suitably-formed die, presses the flanged edge of the plate against the matrix, and so smooths it.

In order to flange the portion of the front head which is to be riveted to the furnaces, both of the vertical cylinders can be coupled together, and by the use of a matrix this flange can be pressed out in one operation. In a similar way the dished and flanged heads of the upper drums in water-tube boilers are pressed in one heat. For the special manufacture of water-tube boilers there are special hydraulic presses, on which the manhole in the head can be flanged simultaneously with the edge of the plate. Fig. 7 shows in section how, through the downward movement of the upper die, and the upward movement of the under die, the plate, shown dotted, is pressed

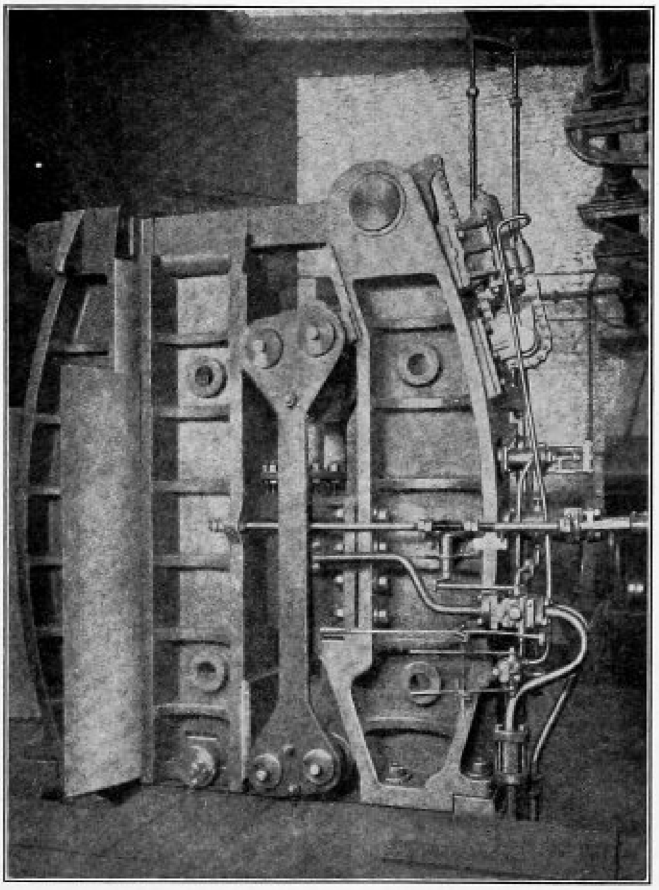


FIG. 8.—HYDRAULIC PLATE BENDING PRESS.

into the form shown by the solid black lines. In the same way a head for a mud-drum can be made in one operation. If any part of the boiler cannot be flanged in one heat, as, for instance, the front head, but must be heated a portion at a time, it is customary to finally anneal the plate, since the stresses remaining in the plate are liable to cause cracks. The working of steel at a blue heat should be avoided, in spite of the fact that it does not harm the good quality of steel which can be secured to-day as much as it formerly did.

(To be concluded.)

Locked in a Boiler.

One of the most thrilling experiences which it has ever been the lot of a boiler maker, or for that matter of any other member of the human family, to undergo, has been graphically described in recent issues of the daily press. The account of the incident is as follows:

Arthur McDonald, a boiler maker, aged 24, left the hospital at Pine Bluff, Ark., recently, a nervous wreck. His hair, which at one time was coal black, now hangs over his forehead a soft, glistening white. He will never again be able to return to his calling, and, in fact, will not be able to do work of any kind for several years. He leaves, accompanied by his brother, for Colorado, where he hopes, in a measure, to rebuild his shattered nervous system.

When seen at the hospital, McDonald told the remarkable story of the circumstances which brought about his present condition.

"I am 24 years of age," he began, "and for the past three years have been employed as a boiler maker, principally in railroad shops. I learned my trade when quite young, and, although fully aware of the dangers of a boiler maker's life, I never once dreamed of the awful experience I would go through, or I should never have attempted to drive a rivet.

"The experience to which I refer occurred three months ago at a sawmill below Hope, Ark. A new set of boilers had been put in, and negro firemen were relied upon to attend them. They soon got out of order, and the foreman sent all the way to Pine Bluff to get a boiler maker. There were none available then except those in the railway shops there. As a pretty good sum was offered I laid off from my regular work and decided to make a few extra dollars. This try came near being the end of me.

"When I reached the sawmill I found the boilers in a bad fix. The flues were choked and needed reaming badly. In addition they were caked on the inside, and as there was not enough help present I decided to go into the boiler myself and chisel off some of the cake matter while the negroes were reaming out the flues.

"This worked all right on the first boiler, and I soon had it in good shape. I then went to the second boiler, and told the negroes as soon as they had finished reaming out the second boiler to replace the manhole on the first; fill it with water and fire up for a test.

"I went down on the inside and found the second boiler's flues in an especially bad condition. I must have worked for an hour, and so intent was I that I did not notice the noise of the reaming cease until I was nearly through. My first intimation that anything was wrong came when the candle began to burn dim, and the boiler seemed full of the candle gas and smoke. I turned around to see what the matter was, and, to my horror, saw that the manhole cover had been replaced.

"I crawled along the flues as fast as I could until I reached the spot and attempted to push it up, but was too late—the negroes had it screwed down firmly. I struck the side of the boiler with my hammer and called several times. The sound was almost deafening to me; but I am sure it was hardly heard on the outside. It then flashed over me that the negroes had misunderstood me, and were preparing to make a fire under the second boiler instead of the first.

"The horror of my situation caused me to feel sick for a moment, but I realized that if there was anything to be done it must be done at once, so I crawled along the rust-covered flues to the end of the boiler. In doing this I accidentally knocked over my candle and put it out. With a cry of anguish I reached for it, but it had fallen down among the flues and was out of my reach for good.

Following close upon this I heard the rush of water through the injector, and knew the negroes were filling the boiler. Now was the time to act, I thought, if I intended to get out alive, but my candle was gone, and never before have I seen such darkness as filled that boiler.

"I had not calculated correctly on the time, for the water had been coming in several minutes before I noticed it. I could feel it creeping up among the flues. For a moment I stopped, and, I am not ashamed to admit it, prayed earnestly for deliverance from the awful fate that now confronted me.

"After an agony of suspense I heard the water shut off with a gurgle that to me sounded like the voice of some demon bent upon devouring me. I attempted to jump up, but struck my head a severe blow upon the top of the boiler and cut a gash in my scalp, but I hardly felt it, so alarmed was I at the thought of the next step the negroes would take. The fire!

"Had I been fortunate enough to have possessed a revolver or even a pocketknife, I would have ended it all there, but I was unable to do a thing but yell and beat the sides of the boiler with all my might and main. I was forced to sit and know that under me the negroes were building the fire that would slowly roast me to death.

"I cannot describe my feeling or agony during the following moments. I imagined I could feel the heat under me already. The atmosphere was suffocating, and cold beads of perspiration stood out upon my forehead and trickled down my spine. To me every minute was an hour.

"It was through sheer exhaustion that I ceased beating and panting and leaned back against the side of my iron tomb. I was not long spared this rest, for I could now distinctly feel the air growing warmer. The flues upon which I was seated were above water, and as I reached down and touched one I started with a gasp. It was warm, ever so slightly, but warm, nevertheless. Again I began pounding and calling frantically, until my lungs felt as if they were lacerated.

"The close atmosphere and heat had started a raging headache, and my temples throbbed as if they would burst. I had torn my hands until they were bleeding freely, and my eyes seemed to bulge in their sockets. The thing that stood out grim and gaunt before me was the fire in the furnace that would slowly roast me to death.

"I thought of my old mother, of home and of thousands of things, it seemed to me. The flues were now becoming warmer. I could feel their heat through my clothing, and once more I pounded and yelled. Back and forth like a hyena I crawled, panting, praying and moaning. The flues were now so hot they burned my bare hands, and my head swam from the heat.

"In a moment of desperation I seized my hammer and dealt myself a severe blow upon the head to try and stun myself in order that the last pangs might not be so terrible. The blow only burst the skin and caused me additional pain. Hotter and hotter grew the flues, until I felt that I could no longer stand the agony. Strange and weird figures appeared before my vision.

"At last, more dead than alive, with every nerve racking with agony, I threw myself down upon the burning pipes to hasten the end. My teeth ground together like a vise as the heated iron burned my flesh. I could not have remained there over three seconds, though to me it seemed a lifetime, before I heard, as plain as I ever did during my life, the voice of a brother who died years ago. Somehow the voice sounded perfectly natural. I recognized it in an instant, and felt not the slightest surprise. It said, quickly, 'Cut the flue, Arthur.'

"In an instant I was on my hands and knees. The last ray of hope had dawned before me, now, I knew, a dying man, and with more strength than I ever before commanded or ever shall again, I placed the point of my chisel on a flue just under the water and dealt it a terrific blow. I missed and struck my little finger." He held up the stump. "I pledge my word that I did not feel the pain. The second blow fell true and the third and the fourth, and with the fifth I felt the chisel give. I caught sight of a fiery fork of flame in the flue, and the next instant heard the water hissing and popping as it rushed through the leak into the furnace below.

"The negroes heard the water when it struck the fire and knew there was a leak somewhere. They, of course, opened the water plug and raked out the fire.

"Realizing that I was fast losing consciousness I dragged myself under the manhole, that I might be found as soon as the boiler was opened. I have a faint recollection of seeing a round patch of daylight, darkened by the hand of a negro, and for the following five days I knew nothing.

"I have been in the hospital here for the past three months, and am afraid I am about all in for good. However, the doctors say the mountains and rest will do wonders for me, so I am going to try it out in Colorado for a while."

"If you had your health and strength back again would you return to your old occupation?" was asked. The white head rested for a moment upon a wasted hand, and then the speaker replied:

"Yes, I think I would; I like it, somehow; but there is one thing certain, I would never again enter a boiler without first seeing that the manhole cover was locked up safely in some closet and I had the key inside my pocket."

Layout of an Irregular Offset Piece.

BY J. N. HELTZEL.

Figures 3, 4 and 5 show the plan and side views of the uptake from a battery of boilers and its connection through an irregular offset piece to the stack. The opening in the stack is out of line with the breeching, and the boilers are placed so close to the stack that there is no room to use an elbow or any regular form of connection between the breeching and the stack. Therefore it becomes necessary to use an irregular section, which must be laid out by triangulation. End and side views of this piece are shown in Figs. 1 and 2. The end

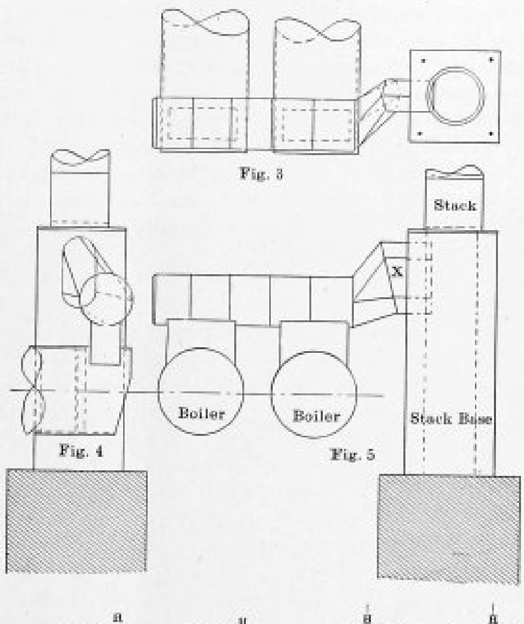


Fig. 3 Fig. 4 Fig. 5

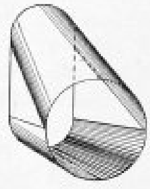


Fig. 1

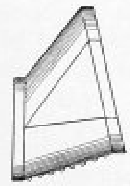


Fig. 2

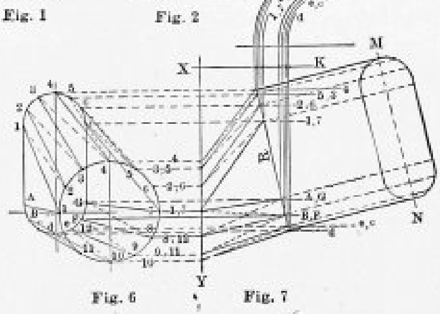


Fig. 6 Fig. 7

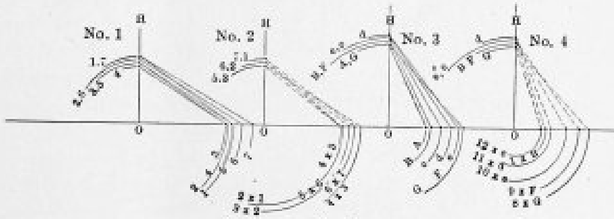
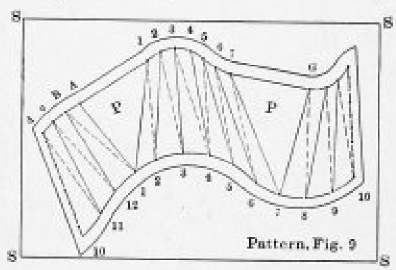


Fig. 8



Pattern, Fig. 9

which joins the breeching is circular, while the end which joins the stack is oblong, with circular ends. The latter is also inclined on a miter line.

To lay out this article, first draw Fig. 6, which is an end view of the piece drawn to dimensions taken at the center of the thickness of the iron, that is the mean or neutral dimensions. Before drawing Fig. 6, however, it is necessary to draw Fig. 7, the side view, and construct the section *M-N*, which is a section taken along the miter line *R* and shows the true shape of the opening in this end of the offset piece. This is an oblong opening with semi-circular ends. Divide the semi-circles into a number of equal parts. In this case each semi-circle has been divided into six equal parts. Project these points to the miter line *R* and from the miter line project them across to the end view, Fig. 6, where by laying off the proper widths on each line the end view of the section *M-N*, as it would appear inclined at the same angle as the miter line *R*, will be shown. Of course, it is evident that the ends of the oblong section in Fig. 6 are not true semicircles, since this is a foreshortened view of the section *M-N*, where the ends are shown as true semi-circles. Divide the large circle, Fig. 6, into twelve equal parts, or double the number of spaces into which the small semi-circles were divided. Number these points 1, 2, 3, 4, 5, etc., up to 11. Also number and letter the points in the oblong end as shown. Connect the corresponding numbers in each semi-circle with a full line and connect the odd numbers, as 1 to 2, 2 to 3, etc., with dotted lines. Some of these points have been lettered instead of numbered in order to avoid confusion in the drawing, as points thus indicated can be more readily distinguished. Draw similar solid and dotted lines in the side view, Fig. 7, being careful to number or letter each point with the same figure which was used in Fig. 6. To obtain the length of the offset for each point on the small semi-circle of the oblong end, draw vertical lines from each point in the miter line *R* to intersect the horizontal *X K*. Then the distance from *X* to each of these lines will represent the amount to be laid off when constructing the triangles for the pattern.

We are now ready to draw diagram No. 1 of the triangles Fig. 8. In diagrams No. 1 and No. 3, the full lines are shown, while in No. 2 and No. 4 the dotted lines are shown. All the distances on the horizontal line of diagram No. 1 are taken from the end view Fig. 6. All the distances on the vertical lines of the diagram are taken from the side view, Fig. 7, along the line *X K* from the point *X* to the point of intersection of the vertical lines drawn from the points on the miter line *R*. For example, take the length of line 4-4, Fig. 6; mark it off on the horizontal line from the point *O*, diagram No. 1, Fig. 8. Now take the distance from *X*, Fig. 7, along the line *X K* to the point where the line 4 intersects the line *X K* and lay it off on the vertical line *O H*, diagram No. 1, Fig. 8. Then the length of the hypoteneuse 4-4 in diagram No. 1 will be the length of the line 4-4 in the pattern. Proceed in this manner until the true length of each of the lines shown in Figs. 6 and 7 have been determined.

The method of triangulation is easier to study from the sketches than from an explanation, and so the explanation is given of how only one line, that is the line 4-4, is obtained, and it is left to the reader to trace out by means of the sketches how the other lines are obtained. As the method is exactly the same for every line, there should be no difficulty in following out this work.

Having completed all four diagrams in Fig. 8, we now proceed to lay out the pattern Fig. 9. Determine the length of the sheet at the round end, by figuring out the circumference of a circle corresponding to this diameter. Set the dividers to step off the same number of spaces on this distance as are spaced on the circle Fig. 6. Do likewise with the small semi-circles. Assuming that *S-S-S-S* is the plate from which the pattern is to be cut, draw the line 4-4 at about the same angle as 4-4 Fig. 6. The length of the line 4-4 will, of course, be equal to the length of the hypotenuse 4-4 in diagram No. 1. With the dividers set to the same length as the equal spaces in the large circle, Fig. 6, draw the arcs 5 and 3. Also with another pair of dividers set to the length of the equal spaces on the small semi-circle, describe the arcs 3 and 5 in the upper edge of the pattern. Take the length of dotted lines 4-3 and 4-5 from diagram No. 2, Fig. 8, and with point 4 as a center, draw arcs cutting the arcs previously drawn with the dividers at points 3 and 5. This locates the points 3 and 5 in the upper edge of the pattern. Points 3 and 5 in the lower edge of the pattern may now be located by laying off the lines 3-3 and 5-5 as taken from diagram No. 1, Fig. 8, to intersect the arcs previously drawn from point 4 through the points 3 and 5. Proceed in this manner with the other lines until the pattern is completed.

The height of the flat portion *P* is taken directly from the miter line *R*, Fig. 7.

In case any of the lines are confused, refer to Fig. 6, which will show the termination of each full and dotted line. A curve drawn through all the points located in the manner just described will be the flange line of the pattern. Add the necessary amount outside of this for the flange and space in the rivet holes in the seams, also allow for the laps.

The portion of the elbow marked *X*, in Fig. 5, which connects directly with the stack, needs no special explanation, as it is a common job of laying out.

Boiler Explosions During 1907.

We present herewith our usual annual summary of boiler explosions, giving a tabulated statement of the number of explosions that have occurred in the United States (and adjacent parts of Canada and Mexico) during the year 1907, together with the number of persons killed and injured by them. As we have repeatedly explained, it is difficult to make out accurate lists of boiler explosions, because the accounts that we receive are not always satisfactory; but, as usual, we have taken great pains to make the present summary as nearly correct as possible. It is based upon the monthly lists of explosions that are published in *The Locomotive;* and in making out these lists it is our custom to obtain several different accounts of each explosion, whenever this is practicable, and then to compare these accounts diligently, in order that the general facts may be stated with a considerable degree of accuracy. We have striven to include all the explosions that have occurred during 1907, but it is quite unlikely that we have been entirely successful in this respect, for many accidents have doubtless occurred that have not been noticed in the public press, and many have doubtless escaped the attention of our numerous representatives who furnish the accounts. We are confident, however, that most of the boiler explosions that have attracted any considerable amount of attention are here represented.

The total number of boiler explosions in 1907, according to the best information we have been able to obtain, was 471, which is 40 more than were recorded for 1906. There were 431 in 1906, 450 in 1905, 391 in 1904, and 383 in 1903. In two cases, during the year 1907, two boilers exploded simultaneously. (See Nos. 284 and 348 in our regular lists.) In each of these instances we have followed our usual practice and counted each boiler separately in making out the summary, believing that by so doing we should represent the actual damage more accurately than we should if we simply recorded the number of separate occasions on which boilers have exploded.

SUMMARY OF BOILER EXPLOSIONS FOR 1907.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Persons Killed and Injured.
January	42	30	9	39
February	50	33	60	93
March	35	30	32	62
April	44	25	31	56
May	25	8	23	31
June	37	19	34	53
July	32	20	33	53
August	38	33	35	68
September	41	23	48	71
October	46	22	28	50
November	40	30	34	64
December	41	27	53	80
Totals	471	300	420	720

The number of persons killed in 1907 was 300, against 235 in 1906, 383 in 1905, 220 in 1904, and 293 in 1903; and the number of persons injured (but not killed) in 1907 was 420, against 467 in 1906, 585 in 1905, 394 in 1904, and 522 in 1903.

The average number of persons killed per explosion during 1907 was 0.637, and the average number of persons injured but not killed per explosion was 0.892.

During the year 1907 there were many very serious explosions, but we are glad to be able to record the absence of any that would compare, in regard to the number of persons killed, with the fearful explosion at Brockton, Mass., in 1905, or with that on the United States gunboat *Bennington* in the same year.—*The Locomotive.*

Spacing Tables.

A spacing table is the only means of obtaining accurate punching on a large class of work. Material, such as plates or angles, where the holes are very close together and where the material is comparatively thick, will stretch in punching, and this stretching, which is accumulative with every hole punched, amounts to considerable on long material. In punching by centers this cannot possibly be avoided. A spacing table compensates for it, however, the stretching of the material merely resulting in a slightly increased length that may be trimmed after punching.

The chief objection to spacers heretofore has been the long time taken for setting. In a busy shop it is wasteful to have a valuable tool and its crew idle several hours every day. To obtain the best results from such machines all the material having the same spacing had to be punched in one lot, a condition not always possible in these days of slow and uncertain delivery. If angles and plates had to be punched all had to be done on the same machine, or else two machines had to be set, with a consequent loss of time. An objection to spacing tables using stops clamped to the side of the machine for spacing is the tendency of the carriage to skew. This, while not important where angle or other shapes are handled, is apt to be troublesome when operating on plates.

The machine illustrated and described in this article was built recently by the Standard Bridge Tool Company, Pittsburg, Pa., for use in connection with a Sellers multiple punch in the new structural shop of the Jones & Laughlin Steel Company, in Soho, Pittsburg. The machine is known as the Thomas spacer, and was designed to carry angles up to 8 by 8 inches in size and plates up to 50 inches wide. A slight modification in the arrangement of the rolls will permit handling plates up to 80 inches wide. These tables are built in 5-foot sections, and can be made any length desired. The design can be modified to suit different classes of work, such as angles, plates, beams, channels, etc.

With the machine illustrated the time required for setting is almost nil, and the responsibility for the proper spacing is placed where it rightly belongs—on the templet maker. A templet strip, ¾ by 2 inches, is prepared by the templet maker, short pegs are driven at the required points, and this is fastened to the side of the table by clamps provided for the spacing on the inner and outer course sheets varies.

The spacing carriage can be equipped with two or more spacing fingers if desired, which will permit obtaining an equal number of different spacings from the same templet strip without changing or disturbing the templet after clamping. This becomes especially desirable when punching the two legs of an angle on which different spacing occurs, and for stacks, round tanks, boilers and similar work on which the spacing on the inner and outer course sheets vary.

After adjusting the guide roller and gag heads and die blocks the machine is ready to start, the whole time for setting not taking at most more than a few minutes. The advantage of using a templet that can be taken off is obvious. If all the material to be punched from any one templet is not at hand, or if only a few pieces are wanted, the machine can be changed often, the time lost is small, and the same spacing is resumed at subsequent settings—conditions not possible where stops are used.

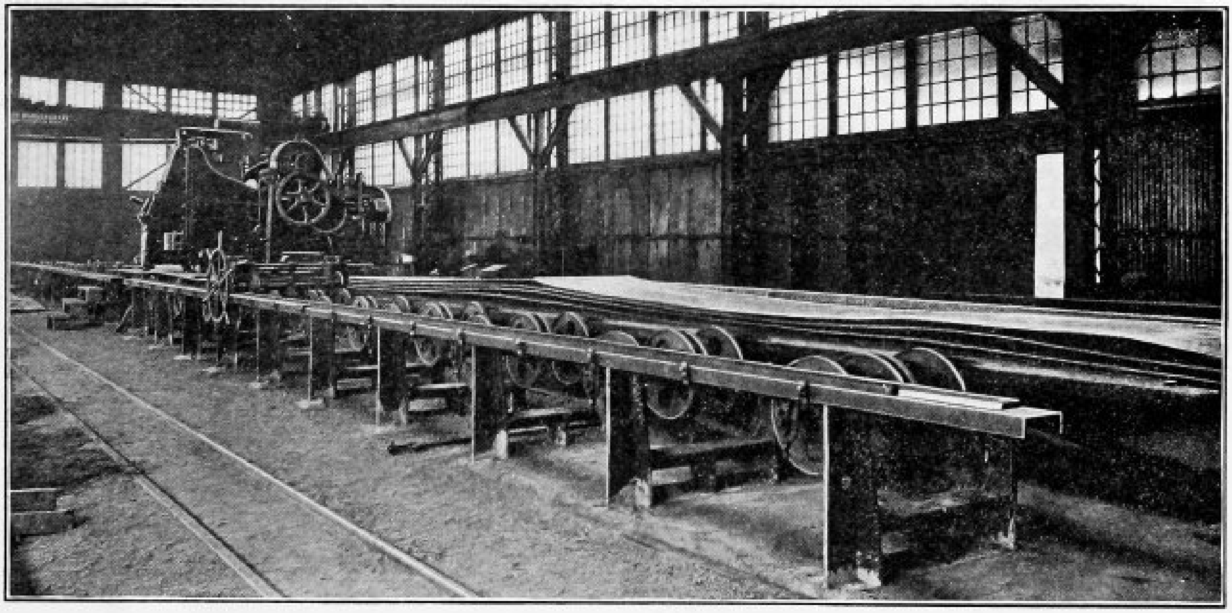


FIG. 1.—THOMAS SPACING TABLE IN THE STRUCTURAL SHOP OF THE JONES AND LAUGHLIN STEEL CO.

The spacing carriage locks automatically at each peg on the templet. This is beyond the control of the operator, and no error can occur from stopping at the wrong place, or from the carriage rebounding or skewing. The carriage is held securely at the stopping points by pawls engaging a hard steel rack running the full length of the table on each side. Six or eight pawls are used, and these are staggered in such a way that the greatest possible errors cannot exceed 1/32 or 1/64 inch. The pawls are located on each side of the carriage and one engages on each side at every stopping point, thus keeping the carriage always square and also providing a positive and absolute stop, which operates automatically.

The larger type machines for handling heavy material are built on the same lines, except that a motor is provided for operating the spacing carriage, the forward motion being controlled directly by the operator through a clutch.

It will be noticed that on this machine angles are handled with the leg up. This is a decided advantage wherever possible. By providing skids of the same height as the rollers on

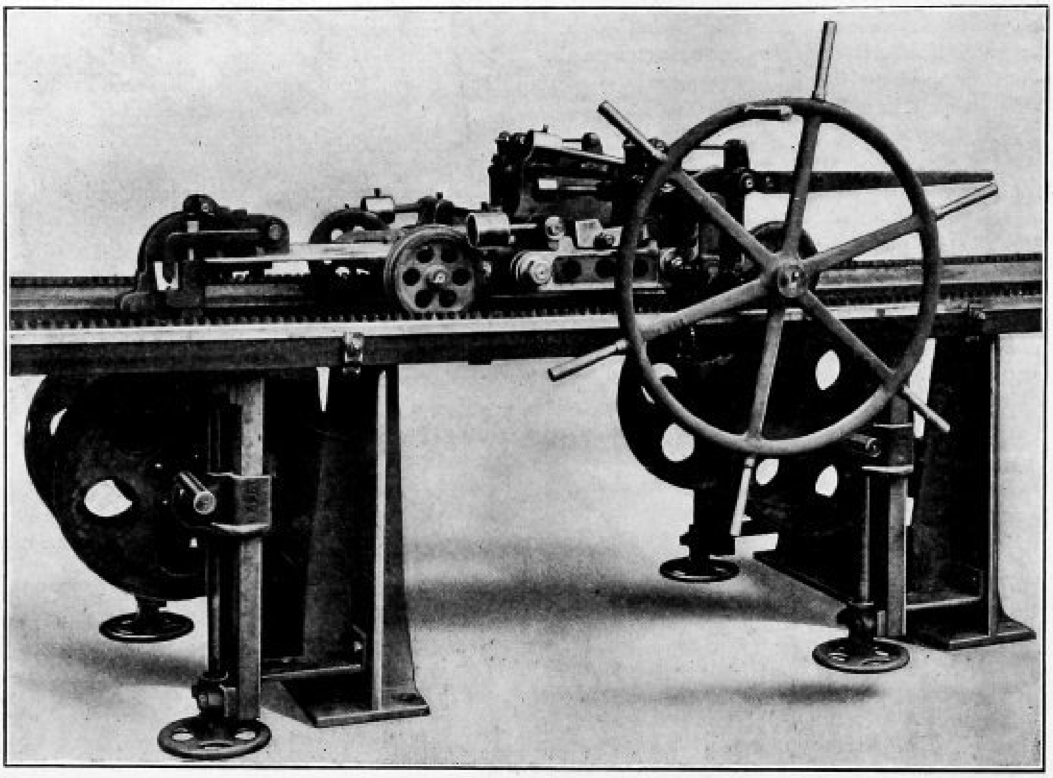


FIG. 2.—THE SPACING CARRIAGE AND A SECTION OF THE TABLE.

the spacer, the material can be skidded on and off, avoiding the use of an overhead crane and such delays as it might entail. In punching with the leg down, necessitating the use of double rollers, this is not possible, and a crane must be used for lifting the work on and off. Another advantage occurs in punching heavy angles where holes are spaced close together and curving of the material cannot be avoided; the flat rollers allow free passage, where the double rollers would quickly bind. Usually such angles can be spaced and curving avoided by punching the angles in pairs, back to back, on a

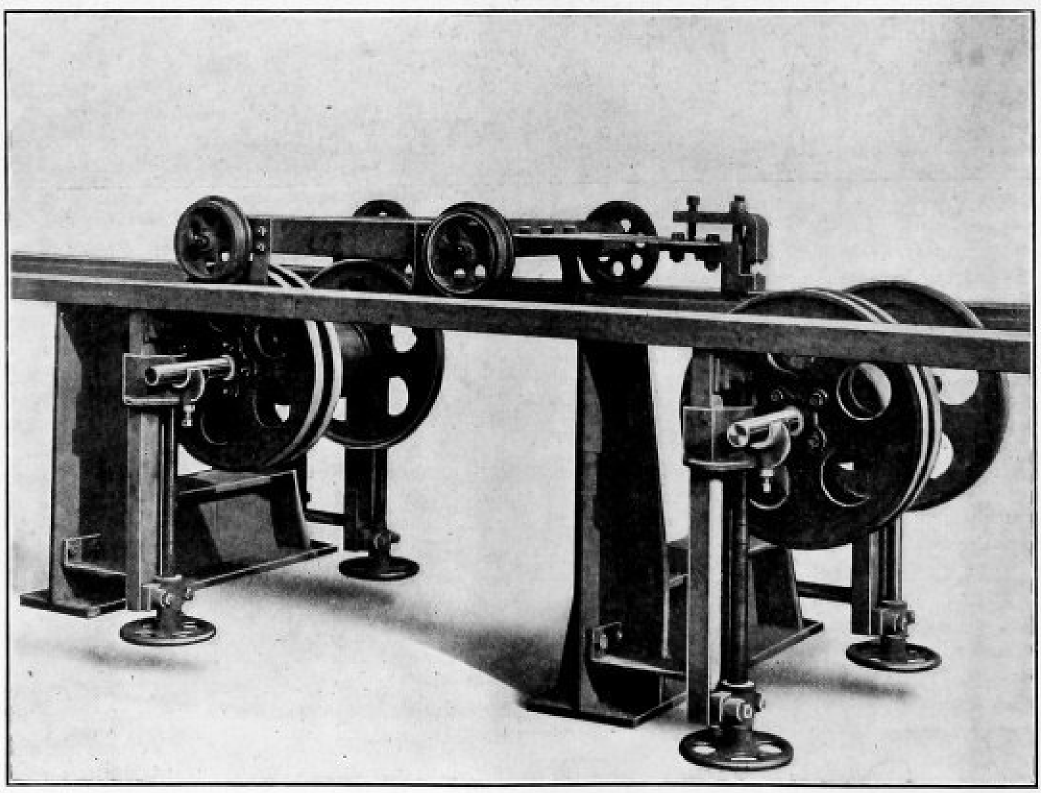


FIG. 3.—THE TRAILER CARRIAGE AND A SECTION OF THE TABLE.

multiple punch, and providing proper means for gaging at the punch. This is the only way to accurately punch such pieces.

The jaws securing the material to the carriage are pivoted to permit free and easy stripping of the material and avoid lifting of the carriage. This arrangement is modified to suit the material handled. On spacers for handling plates, clamps bolted to a thin plate secured to the carriage are provided. This arrangement, while providing a secure grip on the material, provides a flexible connection to the carriage for easing the stripping. The rollers, as shown in the engravings, are also subject to variations to suit the conditions. These are turned and mounted on cold rolled shafts, and vertical adjustments to the height of the dies are obtained by set screws.

It is the general impression that spacing tables can be used to advantage only for duplicate work. The claim is made for the Thomas spacer that a single piece, either an angle or a plate, can be punched on this machine cheaper than the usual templet could be made and the piece marked and punched by centers, not taking into consideration that the piece will be punched more accurately.

The most conspicuous gain from the use of a spacing table is the reduced cost of punching. Where it costs from 90 cents to $2, and even more, per 1,000 holes to punch by centers, the same work may be done for from 20 to 40 cents on the spacer, and this is only one of the several economies obtained. The increasing price of templet lumber, added to the cost of making templets for marking material for punching by centers, becomes a considerable item. Marking the material alone, and the consequent handling for marking, figures on the average very nearly, if not quite, one-half the cost of punching.

While the spacing table will never entirely eliminate templet making and marking, it will in a well-organized plant greatly reduce the amount of such work, and the better the organization the greater will be the reduction. The system must begin with the drafting room, and in the designing due regard must be given to the facilities in the shop for doing the work.

Other important operations directly affected by the use of a spacer in the fabricating shop are the assembling and reaming. In the ordinary process of templet making, marking and punching by centers, small errors cannot possibly be avoided, and these errors will appear in the assembling, greatly increasing the cost of the latter by necessitating the reaming of the holes. It is possible to do accurate punching without a spacer and have holes match when assembling, but ordinarily extreme care must be exercised, and it is a question if reaming would not be cheaper.

A spacing table handled intelligently eliminates costly operations, which have heretofore been considered necessary. This means that the men directly in charge must adapt themselves to new conditions to get the full benefit from the tool. With a little perseverance it is possible to obtain important results; the templet-making will be greatly reduced, the marking and handling for marking entirely eliminated on some work, punching reduced 50 to 75 percent, straightening eliminated by preventing curving of angles in punching, assembling greatly reduced by accurate punching, and reaming entirely eliminated on a large class of work when it is not specified.

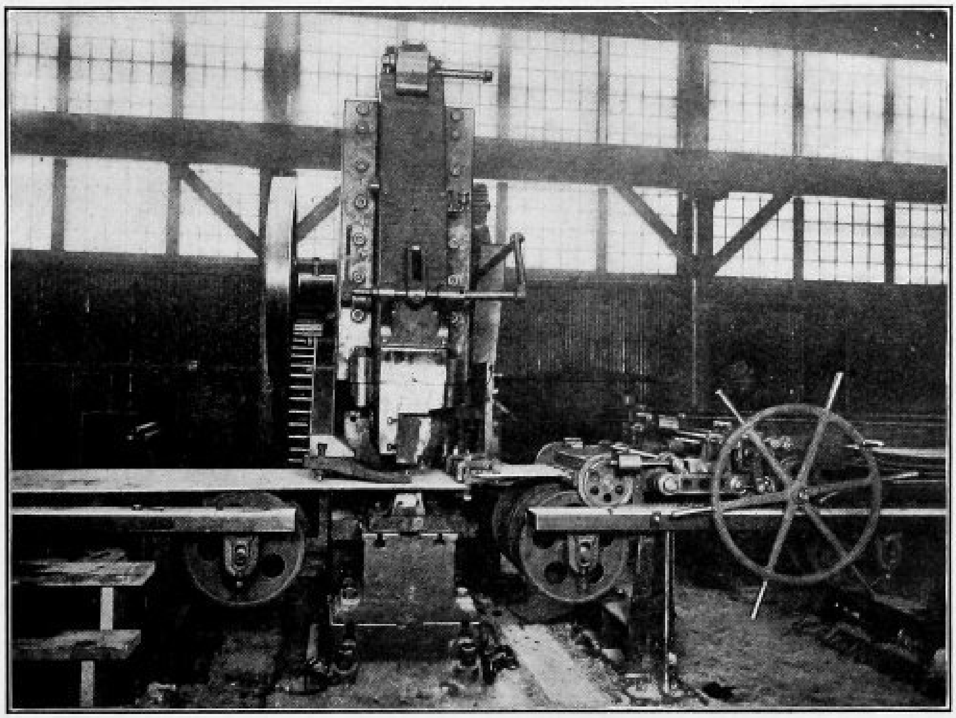


FIG. 4.—PLATE ATTACHED TO THE SPACING CARRIAGE READY FOR PUNCHING.

The Development of Railroad Boiler Shop Practice in the United States.

Boiler-shop practice has probably made greater advancement than that of the other railroad shops, as the use of air motors and hammers has quite revolutionized the methods and increased many fold the output per man. The old method for clipping by hand the calking edge of new boiler sheets was replaced some years ago by the plate planer, which has in turn been superseded by rotary bevel shears for a large percentage of the work, and which can bevel irregular sheets as well as straight ones. Old fire-boxes are now cut out with an air ram and fish-tail chisel bar by two men in about one-quarter of the time formerly required by three men using hand tools. However, some shops prefer to use an eccentric stay-bolt drill to cut out fire-boxes, and claim to make as good time as is possible with the air ram and chisel-bar. One of the greatest improvements in boiler-shop practice has been made in the manner of laying out sheets for new boilers. Formerly the best boiler makers thought they were doing well to get the correct diameter of two boiler sheets, after which the holes were put in one and the other marked from it. Tin strips were used to measure and space the holes, and three or four days were required to lay out and fit a wagon-top sheet, whereas it is now easily done within a day. The old way of riveting by hand required two boiler makers, one helper and a rivet heater, and they drove about 60¾ inches of ⅞-inch rivets in a day. This method was superseded by "snapping" the rivets, which took one boiler maker, three helpers and a heater and increased the day's output to about 225 rivets. But the hydraulic riveter, using one boilermaker and one helper, drives 500 rivets a day, does better work and saves about $100 on a modern locomotive boiler. A long-stroke air hammer uses the same number of men as the snap, and does a little more work, but does not drive as many or make as good a job as the hydraulic riveter if rivets are 1 inch or larger.

Flues used to be welded by a blacksmith on an anvil or brazed by a coppersmith. They are now welded in a rotary or air machine at the rate of fifty or sixty an hour. The old gooseneck for cutting flues out of boilers has been displaced by the air motor and cutter in the front end and the air hammer and chisel are used in the fire-box.

The noisy and dusty dry rattler is still commonly used for cleaning flues, but will eventually be superseded by the rattler running in water. These improvements, together with air flue setting, have reduced the cost of removing, cleaning, piecing and resetting flues in the boiler to less than $15 a hundred.

Layout of a Granet or Hood for an Oval Smoke-Stack.

BY JAMES CROMBIE.

A new style of funnel or smokestack is gradually supplanting the old round smokestack on the steam trawl vessels around the British coast. The stack is of an oval shape and has an outer casing with an air space between the outer and inner stack to carry off the hot air from the stokehold and engine room. A granet or hood is riveted to the inner stack at the top. Fig. 1 shows the arrangement of smokestack and granet.

DEVELOPMENT BY TRIANGULATION.

We will suppose that the oval is of the shape shown in the plan, Fig. 2, with the granet sloping at the angle shown in the elevation, Fig. 2. First divide one-quarter of the inner ellipse of the plan into as many parts as convenient, numbering each point; in this case we have eight spaces. Keep the dividers set at this size. Take another pair of dividers and step off the same number of spaces on the outer ellipse, then connect the points with solid and dotted lines, as shown in Fig. 2.

Next draw a straight line as at *M-N*, Figs. 3 and 4, and erect a perpendicular the same height as required for the granet, namely, 8 inches. From the point of intersection on the line *M-N* lay off a distance equal to the length of the dotted line *O-1* in the plan; do the same with each of the dotted lines, numbering the points to correspond with the plan. This gives us the length of the bases of a series of triangles. Connect these points with the vertex *O* by dotted lines. Do the same with the solid lines, numbering them as before but keeping to the right-hand side to avoid confusion. See Figs. 3 and 4.

To lay out the pattern, lay out a line at Fig. 5 equal in length to the line *O'-O*, Fig. 4, then from the point *O'*, with a radius equal to the length of the dotted line *O-O'*, Fig. 3, strike an arc at the point *O*. With a radius equal to the length as found on the dividers for the outer edge of the plan strike an arc. Then from the point *O'*, through the intersection of these arcs, draw a dotted line as *O'-1*, Fig. 5.

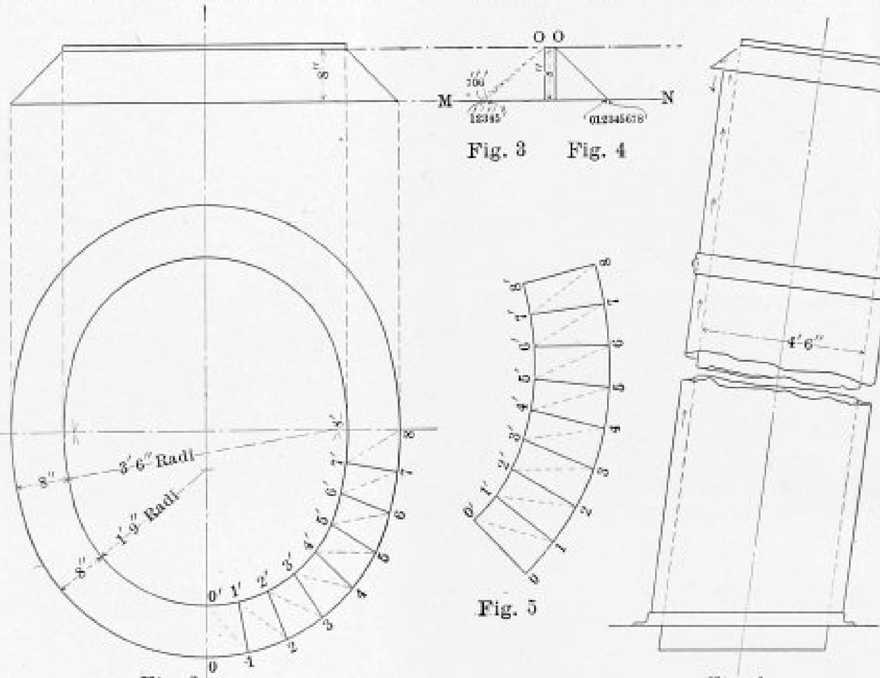


Fig. 3 Fig. 4 Fig. 5 Fig. 2 Fig. 1

DETAILS OF STACK, GRANET, AND LAYOUT BY TRIANGULATION.

Instead of having fusible plugs in the bottom of a boiler over the fire, it is proposed by Mr. Yarrow to place a small pipe inside the shell, having one end closed by being sealed to the shell by a suitable fusible metal. The other end passes through the shell and is furnished with a cock, or it may be led to an alarm or to a feed pump. When the water falls below the safety point the rise of temperature in the boiler acts in the usual way on the fusible metal, but the pipe being protected from the heat of the fire, escapes injury, and when the cock is closed the boiler can be used for steam raising without stoppage for insertion of a new plug.

The plant of the Waley Boiler Works, Providence, R. I., was recently completely destroyed by fire.

With 1 as a center and a radius equal to the length of the solid line *O*-1, Fig. 4, strike an arc. With *O'* as a center and a radius equal to the length as found on the dividers for the inner curve of the plan, strike an arc. Then from the point 1 through the intersection of these arcs draw a solid line as 1'-1, Fig. 5.

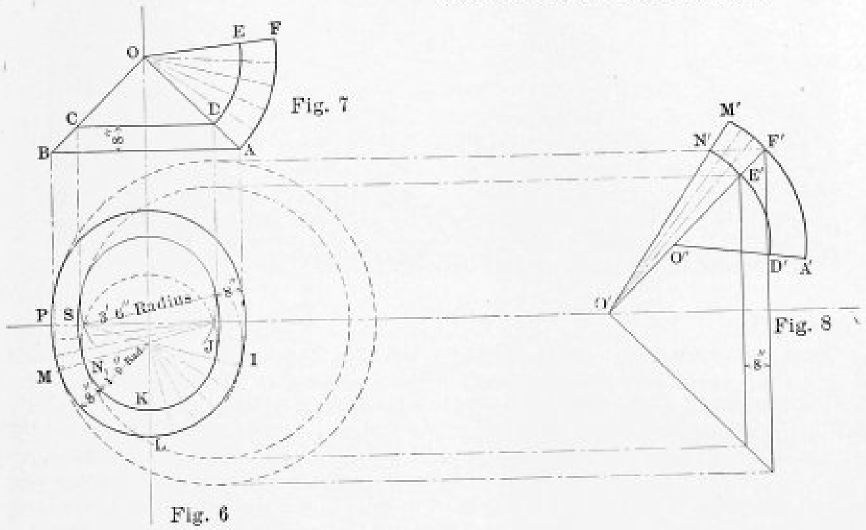
Do the same with the lines 2'-2, 3'-3 to 8'-8. Then draw a smooth curve through the points so found; this will give the required pattern for one-quarter of the granet. The breadth of the flange can easily be added to the inside edge, this depending on the size of rivets used, as the plate may be 3/16 inch or ¼ inch thick.

draw a straight line from the vertex *O"* to *A'*. This will give us the required stretch-out or pattern for one-quarter similar to the pattern found by triangulation.

If the vertex of the large cone extends too far to be laid out with the trammels it may be laid out as an ordinary tapered plate, with a square and compass.

The work may be proven by measuring the curved line of the plan with a steel tape, or hoop, and then measuring the same curve on the stretch-out. They should be the same length.

In actual practice this is a simple problem and can be laid out with very little drawing. It may be done very quickly and accurately by the second method.



DETAILS OF LAYOUT BY METHOD OF RADIAL LINES.

DEVELOPMENT BY THE METHOD OF RADIAL LINES.

This pattern may also be laid out by taking each diameter and treating it as a separate cone and combining the two figures to form one pattern. Fig. 6 is the plan of our granet. Fig. 7 shows the elevation of the small diameter. Fig. 8 shows the elevation of the large diameter. We will take up first the small diameter at the elevation, Fig. 7, and extend the sides until they intersect, thus forming a cone with the vertex at *O*. The required distance around the base of the cone may be measured on an arc whose radius is equal to the length of the elements of the cone. Such an arc may be described for the stretch-out of the cone from the same vertex; this is shown clearly in Fig. 7, where from the vertex *O* with the radii *O-D* and*O-A*, the stretch-out is described.

We now turn to our plan, and from the center of the large circle and through the center of the small circle draw a straight line, extending it to the outer edge of the plan as shown in Fig. 6; take a pair of dividers and divide this part of the plan into any number of spaces. With the dividers set to these spaces step off the same number of spaces on the stretch-out. A straight line from the vertex *O* through the point thus found will give us the pattern *A, D, E, F* equal to that part of the plan marked *I, J, K, L*.

Extend the lines of the elevation of the large figure, Fig. 8, until they intersect at *O'*. From the point of intersection with radii equal to the length of the sides *O'-E'* and *O'-F'* describe the stretch-out. Then step off the remaining portion of the quarter plan and transfer as before to the stretch-out; this will give the pattern for the side piece of the granet. To get a pattern for one-quarter we must combine the two pieces.

Take a radius equal to the length of the side of the small cone and transfer it to the line *O' F'*, Fig. 8, giving the point *O"*. From *O"* as a center and with the trammels set to the lengths *O" F'* and *O" E'*, respectively, strike the arcs *F' A'* and *E' D'*, making *F' A'* equal in length to *F A*, Fig. 7. Then

Relative Corrosion of Wrought-Iron and Soft Steel Pipes.*

BY T. N. THOMSON.

The physical properties of wrought-iron and steel pipes have been brought to my attention during the past few years, and I have spent considerable time trying to determine whether modern soft steel pipe is really superior or inferior to modern wrought-iron pipe for heating and plumbing purposes. The matter was originally brought to my attention by the pipe manufacturers, who stated that we are wrong in supposing that steel pipe is less durable than wrought-iron pipe. Indeed, they showed me the results of numerous tests which demonstrated that, as far as corrosion is concerned, the life of wrought iron and the life of soft steel are practically the same when the pipes are subject to the same conditions.

I did not doubt the records of these tests at all, but as they were principally laboratory tests I could not consider them as convincing as the condemnation of steel pipe by steamfitters and contractors. Then we tried to investigate along practical lines. I had not gone far when we found that a peculiar condition of affairs exhibited itself as follows:

1. A large proportion of the members of the heating trade denounced steel pipe, because, as they said, "It splits, breaks the teeth of the dies and rusts out too quick." Contractors who would acknowledge that they carried steel pipe in stock a few years ago could scarcely be found; they invariably all supposed they carried only wrought-iron pipe.

2. Engineers and architects very freely specified that "wrought-iron pipe (not steel pipe) must be used, etc., their impression being that the increased cost of wrought-iron pipe over steel pipe was more than compensated for in the greater period of usefulness of the wrought-iron pipe over steel pipe.

* Read at the January, 1908, meeting of the American Society of Heating and Ventilating Engineers, and reprinted by courtesy *The Heating and Ventilating Magazine*.

3. Instructors in trade schools, professors in colleges, and even the writers of text-books were known to emphasize the supposed fact that steel pipe was not as durable as wrought-iron pipe, and that the latter should be used in preference to the former, particularly for underground work.

4. On the other hand, statistics showed that the makers of steel pipe furnished about 80 percent of all the welded pipe then used in America. I also found that not only had the makers of steel pipe spent millions of dollars in the development of vast plants, but that they had also made a large number of experiments and tests to determine the relative durability of wrought-iron and steel pipes, and that their findings were invariably to the effect that the life of these two materials is about the same when they are subject to equal conditions.

5. Wrought-iron pipe and steel pipe resemble each other so closely that many engineers, contractors, architects, and even steamfitters themselves, cannot distinguish a difference. I know this to be a fact, for I have tried a number of high-class representatives of these several vocations, and they almost all acknowledged that they could not determine the difference unless they were first to cut and thread the pipes; then those pipes which appear most difficult to thread they would christen steel pipes, while those which appear more easy to thread they would call wrought-iron pipes. But this process of determining a difference is not reliable, for it is a fact that a man working with sharp and properly designed dies can thread steel pipe almost as easily as he can thread wrought-iron pipe. This was demonstrated by a series of tests I made for the International Correspondence Schools in 1905, full records of which can be found in the 1905-1906 proceedings of this society.

METHOD OF INVESTIGATION.

As by far the greater part of the every-day work of our students in heating and ventilation is principally the manipulation of welded pipes, we considered this subject of sufficient importance to investigate and try to find something absolutely definite regarding the relative corrosion of modern wrought-iron and modern mild steel pipes when both are subject to the same actual working conditions as they occur in practice. With this end in view we commenced by quietly circularizing about 300 heating engineers and contractors, offering a book to each in exchange for a small piece of corroded pipe which had been in service only a few years, we to pay express charges at our end. Each circular letter was accompanied by a sheet with printed questions relating to the history of the sample, and was provided with blank spaces for the answers.

My object in trying to obtain these samples and their histories was to find how many were wrought iron and how many were steel. I expected to find that at least 80 percent of the samples of corroded pipe sent to me would be steel, but they were not. Of the samples received, only ten gave out within four years of service, six of these being steel and four being wrought iron. An examination of these samples showed that uniform corrosion took place in both the wrought-iron and the steel pipes.

A study of the samples received from the trade would lead me to assume that (1) both wrought-iron and steel pipes which convey steam or hot water will corrode very rapidly when buried underground in wet or damp soil or ashes, the corrosion being principally external; (2) both wrought-iron and steel pipes which convey hot water become rapidly corroded if the air and other gases naturally solvent in the water are not permitted to escape from the water previous to its passage through the pipes, as in feed-water heater connections and hot-water circulation pipes for plumbing purposes, this corrosion being principally internal if the pipes are not buried underground. (3) That the life of either wrought-iron or steel pipes subject to both of the aforesaid conditions will be much shorter than if the pipes are subject to only one of them, because the metal will thus become rapidly corroded at both the internal and external surfaces. (I received no samples which show this, neither have I made tests to prove it, but it seems rational to form this opinion at present.) (4) It is not a fact that the destruction of wrought-iron pipes is in the form of a uniform corrosion, while the destruction of steel pipes is in the form of pitting; they appear to be on an average nearly alike, with the dfference, if any, in favor of steel.

Of course no definite conclusion can be drawn from the study of a number of pieces of corroded pipes received from different parts of the country further than the facts we can see in the samples themselves; for instance, the finest sample of uniform corrosion I received was mild steel. It came from Milwaukee, Wis., is ¾-inch black steel pipe and is reported to have been used "for heating water in a range boiler for domestic purposes." It was in use two years. The corrosion is practically uniform without a sign of pitting. Part of the original thickness of the metal was corroded from the inside and about two-thirds from the outside. The pipe, which, no doubt, was originally standard weight, is now about 1-16-inch thick at its thickest part and tapers down to tissue paper thickness in several places.

To secure a record of facts regarding the period of useful-

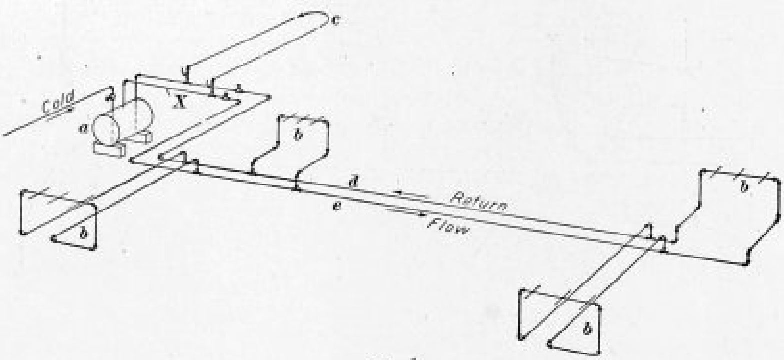


FIG. 1.

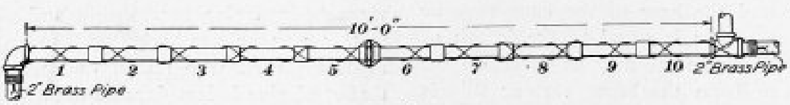


FIG. 2.

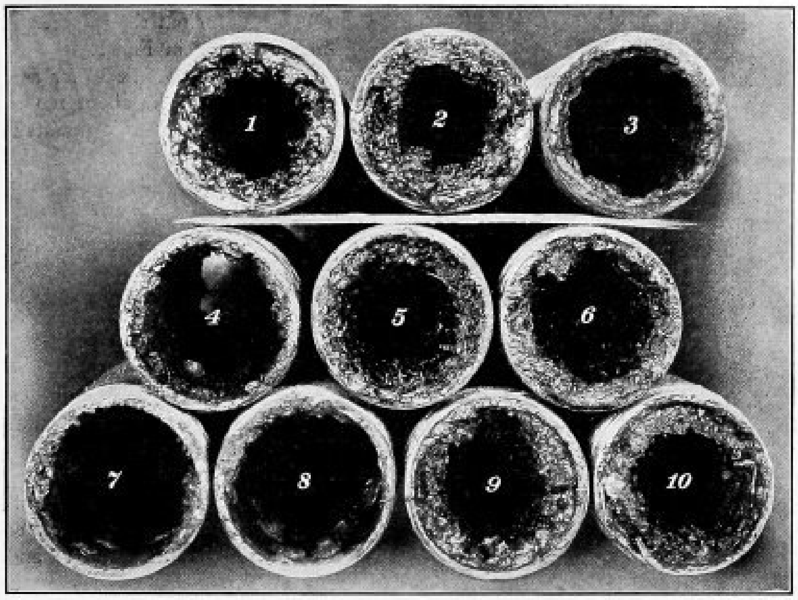


FIG. 3.

ness of steel pipe as compared with wrought-iron pipe it is necessary to test a large number of samples of both steel and iron pipes subject to exactly the same conditions, and these conditions must be the same as the conditions of practice.

On March 7, 1906, I installed a number of pieces of wrought-iron and steel pipe for a corrosion test at the ceiling of the engine room in the Instruction building of the International Correspondence Schools in Scranton, Pa. (Fig. 1), with the object of determining definitely whether steel pipe will last as long, or longer, than wrought-iron pipe, and by how much. The existing conditions were as follows:

A 100-gallon galvanized iron boiler *a* in the engine room is

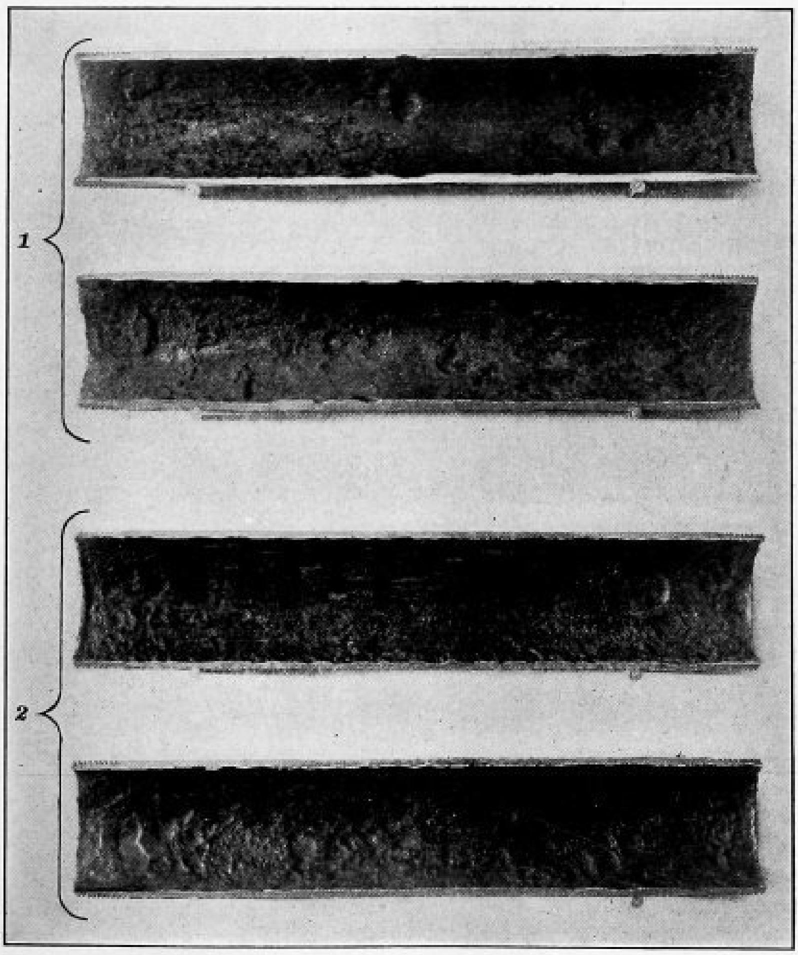


FIG. 4.

set horizontally on two cast-iron cradles supported on brick piers. This boiler furnishes hot water to twenty-four combination cocks at four press-room sinks as at *b* and four slop sinks *c*. The water is heated by a 1-inch brass steam coil inside the boiler. The water comes from our city mains and has a working pressure varying from 85 pounds to 135 pounds per square inch by the gage. This water comes from enormous reservoirs in the mountains about 12 miles away. An analysis of the city water made while the pipes were under test was as follows:

TABLE I.

	Parts per Million.
CO_2 and Organic matter	29.33
Silica	4.00
Iron oxide	0.43
Alumina	0.37
Calcium carbonate	4.82
Magnesium	Trace
Sulphur trioxide	Trace
Sodium chloride	0.82

This may be classed as ordinary good water and should not affect iron or steel pipes in any extraordinary way.

The water on being heated in the boiler *a* circulates between the boiler and the sink cocks to insure hot water being drawn instantly when a cock is opened. The circulation is from the top of the boiler up through the flow pipe *d* and back through the return pipe *e* to become reheated in the boiler. These pipe lines are all composed of annealed brass pipe, tinned both outside and inside and connected with heavy cast brass beaded fittings. A piece of 2-inch pipe 10 feet long was removed at *x* and replaced with ten short pieces of 2-inch iron pipe screwed together as shown in Fig. 2.

The temperature of the water as it flows through this pipe varies presumably from about 160 degrees to 212 degrees, and the supply of hot water is maintained day and night all the year around.

Owing to the fact that these iron samples were connected to brass pipes, and also because a large number of presses and other printing and book-binding machinery driven by individual electric motors are used in this building, we wired and cross-wired the pipes with copper wire as shown, connecting the ends with perfect contacts to the brass pipes at *g* and *h*. This was done under advice from electrical experts to carry any stray current around the samples and thus avoid decomposition due to litic action. It was thought this precaution would insure a corrosion that would be due to nothing but the ordinary action of the hot water on each sample, and that no sample would be favored in any way. The samples were installed March 7, 1906; were removed March 14, 1907, and were in constant service during that time.

As soon as they were removed and separated, the ends were photographed (see Fig. 3) to show the rust formation and its thickness. The velocity of the water through the samples was always low; it never was high enough to wash out or dislodge the rust, which, therefore, formed a fairly uniform lining about ⅜ inch thick in the black samples. The galvanized samples were not affected this way; they corroded only in spots which presumably were imperfections in the galvanizing.

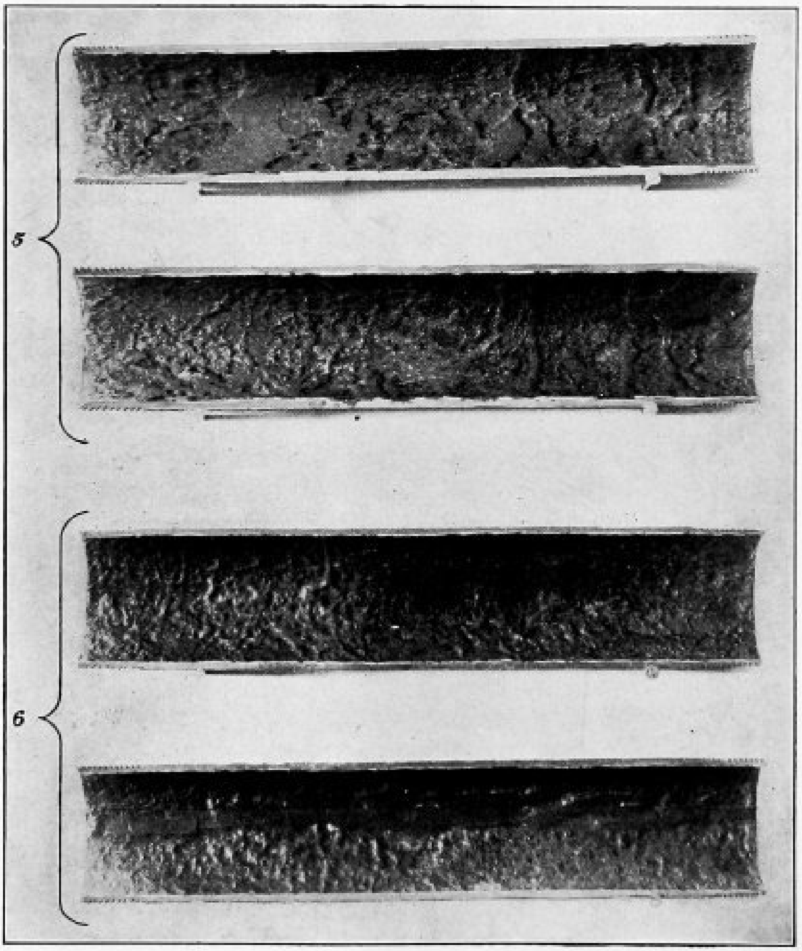


FIG. 5.

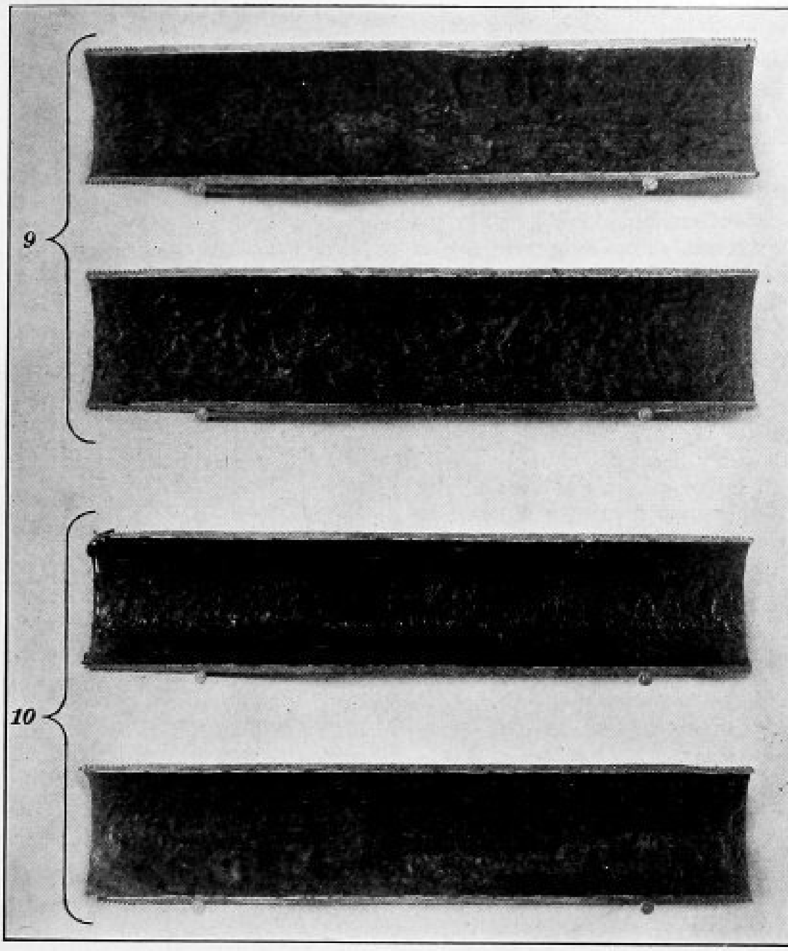


FIG. 6.

Before installing the samples we weighed each one separately without the couplings, so that after the rust was all washed out and the samples weighed again the difference in weight indicated the total weight of metal lost by corrosion. Here we found that in the plain pipes 9 13-32 pounds of wrought iron lost 20¾ ounces, while 9 11-32 pounds of steel lost 24⅞ ounces. (The galvanized samples are not included here because the zinc coating affects their durability.)

This is where we are tempted to stop short and conclude that as the steel pipe in this test has lost more metal than the wrought-iron pipe, it follows that the wrought-iron pipe is the more durable. But such a conclusion would be misleading and absurd in the extreme, because the life of a pipe depends not upon the amount of the corrosion, but upon the deepest pitting. A certain pipe may lose only 1 percent of its weight by corrosion when it begins to leak from some pittings, while

TABLE II.

	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		No. 10.	
KIND OF PIPE.	Blk W. Iron.		Blk. Steel.		Galv.W.Iron.		Galv. Steel.		Blk. W. Iron.		Blk. Steel.		Galv.W.Iron.		Galv. Steel.		Blk. W. Iron.		Blk. Steel.	
Weight without coupling when put in............	$3\frac{13}{64}$ lb.		$3\frac{3}{32}$ lb.		$3\frac{15}{32}$ lb.		$2\frac{25}{32}$ lb.		$3\frac{3}{32}$ lb.		$3\frac{5}{32}$ lb.		$3\frac{10}{32}$ lb.		$3\frac{18}{32}$ lb.		$3\frac{7}{64}$ lb.		$3\frac{3}{32}$ lb.	
Weight without coupling when removed and rust washed out..............	$2\frac{26}{32}$ lb.		$2\frac{20\frac{1}{4}}{32}$ lb.		$3\frac{13}{32}$ lb.		$2\frac{23}{32}$ lb.		$2\frac{20\frac{1}{4}}{32}$ lb.		$2\frac{19}{32}$ lb.		$3\frac{6}{32}$ lb.		$3\frac{15\frac{1}{2}}{32}$ lb.		$2\frac{21\frac{1}{4}}{32}$ lb.		$2\frac{18}{32}$ lb.	
Loss in weight by corrosion.	$6\frac{1}{4}$ oz.		$7\frac{3}{8}$ oz.		1 oz.		1 oz.		$7\frac{3}{8}$ oz.		9 oz.		2 oz.		$1\frac{1}{4}$ oz.		$7\frac{1}{8}$ oz.		$8\frac{1}{2}$ oz.	
Per cent loss..............	12.2%		14.9%		1.8%		2.2%		14.9%		17.8%		3.8%		2.2%		14.3%		17.2%	
	1	1X	2	2X	3	3X	4	4X	5	5X	6	6X	7	7X	8	8X	9	9X	10	10X
Depth of five deepest pits in each half of each sample in inches...........	.078 .078 .072 .080 .072	.060 .083 .074 .076 .059	.056 .045 .068 .069 .069	.061 .069 .071 .063 .075	.048 .043 .038 .029 .029	.030 .042 .049 .023 .016	.055 .044 .045 .038 .058	.092 .082 .068 .070 .050	.073 .072 .062 .073 .050	.057 .045 .062 .058 .056	.053 .046 .063 .033 .042	.065 .073 .053 .053 .065	.048 .059 .055 .070 .049	.050 .027 .060 .074 .068	.049 .031 .042 .026 .041	.041 .040 .025 .048 .046	.045 .044 .057 .069 .042	.062 .066 .075 .054 .050	.051 .037 .043 .041 .062	.056 .052 .066 .067 .045
	1	1X	2	2X	3	3X	4	4X	5	5X	6	6X	7	7X	8	8X	9	9X	10	10X
Thickness of metal under pits in inches...........	.076 .076 .082 .074 .082	.094 .071 .080 .078 .095	.098 .109 .086 .085 .085	.093 .085 .083 .091 .079	.106 .111 .116 .125 .125	.124 .112 .105 .131 .138	.099 .110 .109 .116 .096	.062 .072 .086 .084 .104	.081 .082 .092 .081 .104	.097 .109 .092 .096 .098	.101 .108 .091 .121 .112	.089 .081 .101 .101 .089	.106 .095 .099 .084 .105	.104 .127 .094 .080 .086	.105 .123 .112 .128 .113	.113 .114 .129 .106 .108	.109 .110 .097 .085 .112	.092 .088 .079 .100 .104	.103 .117 .111 .113 .092	.098 .102 .088 .087 .109

another pipe may have lost 50 percent of its weight by corrosion and still be perfectly tight and serviceable. Therefore, it appears evident that in order to determine the relative life of the samples it is necessary to measure the depth of the pittings and base conclusions on these measurements.

With this end in view, we sawed open each sample lengthwise; then an expert in micrometer measurements, a toolmaker accustomed to very fine work, was detailed to measure the depth of the five deepest pittings in each half, making 100 micrometer measurements. It really was only necessary to measure the deepest pitting in each piece, but to locate it by the eye was impossible. By selecting the five which appeared to be the deepest, however, we felt sure that we measured the deepest pitting in each piece.

The accompanying Table II. is a record of the results of this test.

The thickness of the metal under each pitting was first measured by "Starrett" transfer calipers having sharp points; then a very delicate, small inside caliper was used to just touch the points of the transfer caliper, and the distance between the points of the inside caliper was measured with a 1-inch micrometer. Each pitting was measured in the same way and by the same person. The measurements recorded here are believed to be correct to within 1-1,000 of an inch.

Figs. 4, 5 and 6 are from photos of the samples after they were cut in halves. A close examination will show quite a difference between the corrosion of the steel and the iron.

SUMMARY.

Assuming that corrosion had been continued at the rate which existed during the period of the test, then the different samples would have become corroded through at the end of the number of days given in the accompanying Table III.:

TABLE III.

DURABILITY OF THE SAMPLES.

Plain Pipe.	Days.
No. 10. Steel pipe	850.4
No. 5. Wrought-iron pipe	780.5
No. 6. Steel pipe	780.5
No. 2. Steel pipe	759.7
No. 9. Wrought-iron pipe	759.7
No. 1. Wrought-iron pipe	686.5

The average life of the plain steel pipe samples is 796.9 days, while the average life of the wrought-iron samples is 742.2 days, making a difference of 54.7 days in favor of steel. Therefore, a rational deduction to draw from the preceding facts is that plain steel pipe is more durable than plain wrought-iron pipe when used to convey hot water and subject only to internal corrosion.

I know that the above summary is not in perfect harmony with the opinions of many engineers and contractors, but I can only record the facts as they are found. If any errors can be discovered either in the method of making the test, obtaining the data, or in the deduction, I will be pleased to know them.

A Business Opportunity.

A correspondent wishes to know the names and addresses of any concerns who manufacture as a standard product tanks of suitable weights and sizes in general use for pneumatic pressure water systems. It is particularly desired to get in touch with concerns which make a specialty of this line of work who are located in the East. Any communications sent to THE BOILER MAKER and addressed to "Pneumatic Pressure System" will be promptly forwarded to our correspondent.

Power Requirements of Machine Tools.

It is a rare occurrence nowadays for any manufacturer who is considering installing a new plant or equipment to consider any other form of power distribution than electricity. The various tools and machines which are installed in a boiler shop are seldom run continuously, and, from the nature of the work, must be isolated; therefore, any form of shaft drive is wasteful of power.

It is not always easy, however, to obtain accurate information regarding the size of motor to be used with individual machines. It is hard to find satisfactory formulæ for figuring the horsepower necessary to drive the machines, and frequently

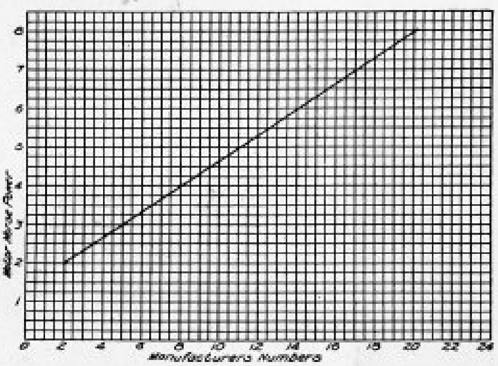


FIG. 1.—POWER REQUIREMENTS OF PIPE CUTTERS.

information given by the builders cannot be relied upon. Under these circumstances the work of Mr. L. R. Pomeroy, who has recently worked out a formula for finding the horsepower necessary to drive different machine tools, will be welcome. Mr. Pomeroy has published this formula together with a few examples showing how it may be applied and the results given, by applying it to a number of different types of machines, in an interesting article in a recent number of the *General Electric Review*. The formula which he has worked out is as follows:

$HP = F \times D \times fpm \times 12 \times N \times K$, where F is the feed in inches; D the depth of cut in inches; fpm the feet per

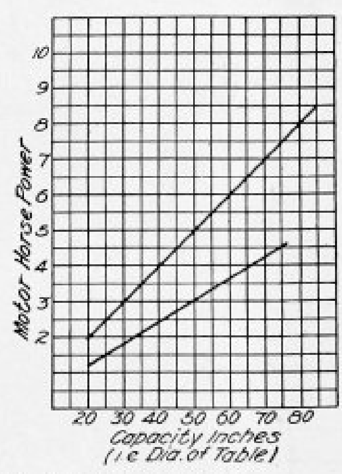


FIG. 2.—POWER REQUIREMENTS OF DRILL PRESS.

minute; N the number of tools cutting, and K a constant which depends upon the kind of material. For cast iron, K varies from .35 to .5; for soft steel or wrought iron, from .45 to .7; for locomotive driving wheel tires, from .7 to 1, and for very hard steel, from .1 to 1.1. As a single example of how the formula is used, take the case of a steel-tire wheel lathe, turning engine truck wheels with a feed of 1/7 inch; the depth of cut of 5/16, the cut taken at the rate of 16 feet per minute; two cutting tools at work, and the value of the constant K taken as 1. The equation for the horsepower required to drive the machine then becomes:

$$HP = 1/7 \times 5/16 \times 16 \times 12 \times 2 \times 1$$
$$HP = 17.$$

In Figs. 1 and 2 curves are given showing the power requirements of two different kinds of machine tools; while in the following table the motor horsepower required has been worked out for a number of different tools which are commonly used in a boiler shop:

PUNCHES AND SHEARS.

	Motor Hp. Required to Drive.
No. 4 36-inch throat L. & A. punch	3
No. 9 horizontal flange punch	5
No. 2 Hilles & Jones combination punch and shear	5
Alligator shear (stock 5 inches by 1 inch)	5
Lenox rotary bevel shear	7½
56-inch multiple tank plate punch with spacing table	7½
No. 3 Hilles & Jones combination punch and shear, 12-inch throat	7½
No. 2 horizontal punch, 20-inch throat	7½
No. 3 Hilles & Jones combination punch and shear, 36-inch throat	10
No. 3 angle shear, 5-inch by 1-inch bar	10

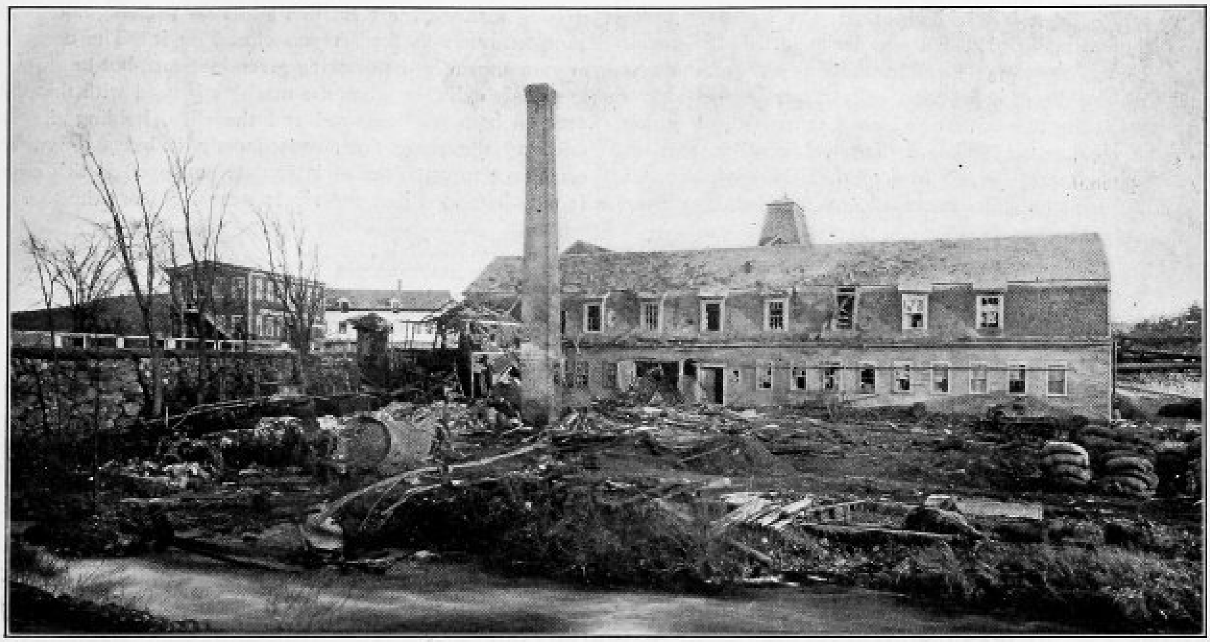
BOLT AND NUT MACHINERY, MULTIPLE DRILLS, ETC.

1½-inch single head bolt cutter	1½
Pratt & Whitney No. 4 turret bolt cutter	2
Two-spindle stay-bolt cutter	2
1½-inch Acme double-head bolt cutter	2½
1½-inch triple-head bolt cutter	3
¾-2½-inch double-head bolt cutter	3
2-inch triple-head bolt cutter	5
Four-spindle stay-bolt cutter	5
Bradley hammer	7½
Niles' four-spindle multiple drill	7½

Disastrous Explosion of Lap Seam Boiler.

On the night of Dec. 9, 1907, at 8.45 P. M., the 85-horsepower boiler of the Hygienic Blanket Company, Hubbardston, Mass., exploded, killing the night-watchman, blowing three buildings to atoms and damaging four others to the extent of a great loss. The boiler itself was blown 57 feet from its foundation, destroying everything in its path and setting fire to the wreckage. The age of the boiler is somewhat uncertain, as it was bought by the Hygienic Blanket Company second-hand and used by them about nine years. The builders of the boiler were unable to trace its history previous to its acquisition by the Hygienic Blanket Company. It was of lap-seam construction, and the boiler inspector who made the examination after the explosion placed the blame of the accident upon this feature of construction. It was evidently the case, altogether too common, of a lap-jointed boiler which had been in use for a long time, the shell plates of which had become cracked on the under side at a point just outside the line of rivets where the plates were lapped, so that the cracks could not be discovered even by careful inspection. The cracks, of course, became deeper and deeper and spread to a greater length every time the pressure was raised or lowered on the shell, until finally the plate was weakened to such an extent that it could not stand even a moderate pressure. It was said that there were two gages of water and about 40 pounds of steam on the boiler when the explosion occurred. The rear sheet was stripped completely off, leaving the flues uncovered. The conditions under which the boiler was operated were very favorable, as only the purest of water was used and the boiler was never allowed to carry over 80 pounds of steam.

The force of the explosion was terrific, as can be seen from the photograph taken the morning after the explosion. The boiler itself was originally installed close to the tall brick stack, but when the explosion occurred it was lifted from its setting and landed about 57 feet away, where its position is shown in the photograph. The safety valve was blown a quarter of a mile away, one-half of the boiler house roof over 600 feet, and several bales of cotton were also carried about 600 feet. A three-story building 110 feet long, and a two-story



THE BOILER WAS HURLED 57 FEET FROM THE STACK TO THE POSITION WHERE IT IS SEEN IN THE PHOTOGRAPH.

building 100 feet long, both built parallel to the street and joining the main part of the mill, were completely demolished and destroyed by fire. The main mill itself would have been burned had it not been completely fitted with automatic chemical fire tanks, which had been installed in the building by J. E. William & Sons, of Hubbardston, Mass., which served to check the flames and save the building.

Some Early Boiler Makers' Machine Tools.

Among a number of early machine tools described in the *London Engineer* the two illustrated in this article are of interest to boiler makers. They are both of French design, and were in use about seventy years ago. The steam punching machine, shown in Fig. 1, which was designed by M. Cave, is very interesting, as it was in all probability one of the first examples of the direct connection of a steam engine with a machine tool. The illustration—which is taken from Rennie's edition of *Buchanan on Millwork, Etc.*, published in 1841—is fairly self-explanatory. It will be seen the steam cylinder is a single-acting one, the slide valve being controlled by a hand lever as shown, and the action assisted by a pair of heavy fly-wheels.

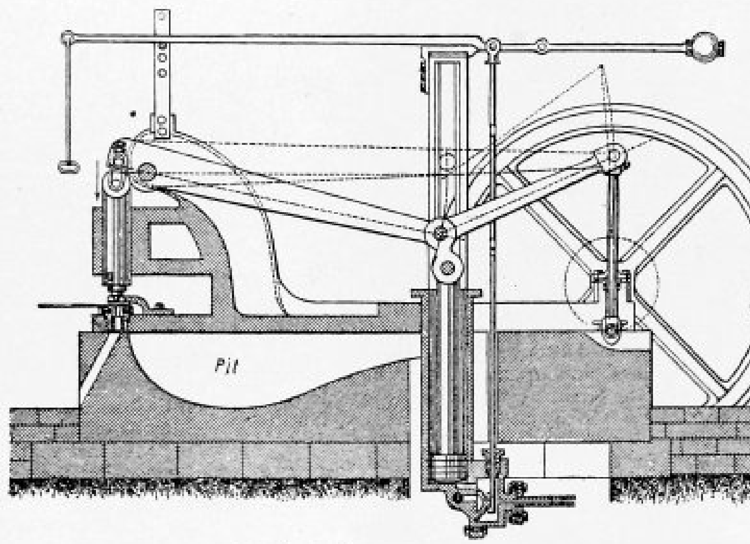


FIG. 1.—CAVE'S STEAM PUNCHING MACHINE.

It is well known that Sir James Nasmyth's steam hammer was invented by him in 1839, and was actually carried into practice by some French engineers without the inventor's knowledge. Whether M. Cave had this in mind in designing the machine just described is perhaps doubtful, but the influence of the English invention is plainly visible in the next illustration, which is taken from Scott's *Engineer and Machinists' Assistant*, 1847, and represents a combined steam punching and riveting machine by M. Le Maitre, also of Paris—Fig. 2.

This machine, which is a marked advance on the one previously described, also depends for its operation on a directly-connected steam cylinder, but the motion is not continuous, the piston-rod acting on a lever of the first order operating the punching and riveting slide. Another remarkable feature is the provision of a "holding up" device to keep the plates tightly together while the rivet is being closed. This is operated by a supplementary steam cylinder of smaller size acting on the longer of the two levers shown in the illustration, and thereby on a ferrule or sleeve through which the riveting set passes. A reference to the sectional sketch will enable the action to be understood.

It will be observed that the punch is hinged to turn back out of the way when not in use. The inventor also made use of a very clever marking device—which is not shown in the sketch—to ensure correct spacing in punching holes, which is very similar to the means at present employed on "gang" or multiple punching machines in this country.

Like the previously described machine, the two steam cylinders are both open-ended and single-acting, the valves being operated by hand levers connected as shown. The inventor likewise employed a simple but very ingenious arrangement to rivet long tubes of small diameter, which may be thus described: In this case the "dolly-bar" or anvil was hollow, and through it passed a long rod forged at its extremity to the shape of a long wedge, which acted on a plunger passing through the rivet die, and thus pressing up the rivet simultaneously as the set was closed on it. The connections are not shown in the drawing given by Scott, but he states that the steam cylinder, when the machine is used with this device, acts on both the long rod and the slide, holding the set at one and the same time, consequently it bears a strong resemblance to machines of later date employed in this country. It may be added that the rivets were fed from the top.

Locomotive Boilers.

BY W. L. FRENCH.

The advance made in the size of locomotive boilers and the methods of construction since boiler making was first commenced is something remarkable. No better illustration of this can be had than to note the boiler dimensions of "Old Ironsides," the first Baldwin engine, and one of the modern battleships. The boiler of "Old Ironsides" had a diameter of 30 inches; number of tubes, 73; material of flues, copper; diameter of flues, 1½ inches; length of flues, 7 feet. Copper entered largely into early boiler construction, so far as the fireboxes and flues were involved.

Now note the boiler dimensions of the modern locomotive, with a diameter of shell, 78 inches; number of flues, 350; diameter of flues, 2¼ inches; length of flues, 20 feet; material, iron; heating surface, 4,800 square feet.

The demand for the movement of larger trains made the building of large engines necessary. Very large steam cylinders with high steam pressure to force the pistons back and forth in them demanded an enormous steam storage capacity to supply their wants, and this in turn required increased heating surface and grate area in the firebox, and so the large boiler with its extended wagon-top, and the wide, shallow firebox grew to their present proportions. That they can grow to any greater extent is not probable, as with the present width of roadbed it would seem that the limit in height has been reached.

The growth from the small to the large boiler has been gradual, and is marked with a number of experiments, many of which proved of no success, yet each one conveyed a lesson. From a tank holding a few gallons of water, the tank has grown to one holding 8,000 gallons of water, and lessening the cost of train operation by reducing the number of stops for water.

Steel is the metal used in this day for boiler construction. Sheets of the required size are shaped, punched and turned to the required form. Often some of the future trouble for the mechanical department of the railroad purchasing the engine is started. The dies for punching holes in the sheets, if dull, cause small fractures that do not show at the time, but later develop into cracks and leaks around rivets; crown bar bolts and staybolts are the result. Drilling these holes would be

With steel sheets in good condition, and crown bars, braces and staybolts in good shape, the danger of a boiler explosion is reduced to a very small one, for the strength is in the metal to resist the pressure, and that is all that is necessary to avoid explosions.

A sheet might be burned or the staybolt heads be melted off, so that there would be a giving away; but if there is, the condition of the steel will speak for itself; there will be no mystery about the cause of the explosion. Breakage of staybolts is a matter of frequent occurrence, but, as most of them are drilled in the end through the sheet, when one breaks it immediately gives warning of that fact without any test and should at once be replaced.

Too narrow a water space in water legs is hard on both staybolts and side sheets, as when working hard the water is liable to be all boiled away from the inner sheet, and the sheet and staybolts, too, become overheated. This is the point of greatest pressure in a boiler, also, as there both the pressure of the steam and the weight of the water are united in force against the sheets and mud-ring.

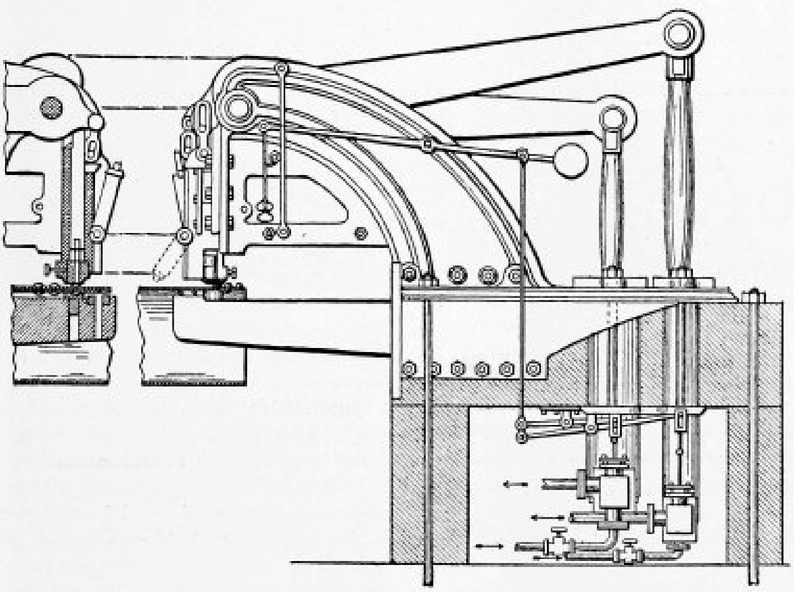


FIG. 2.—LE MAITRE'S COMBINED STEAM PUNCHING AND RIVETING MACHINE.

certain not to injure the sheet, but it is slow when compared with punching.

The crown sheet is often braced by crown bars across its top and bolts through crown sheet. Where this form of bracing is employed the crown sheet is more flat than where radial stays are employed. Where crown bars are used the crownsheet is said to be sling-stayed. When the stays extend from the dome head to the crownsheet, no crown bars being used, the boiler is said to be radial-stayed. The crown sheet of such a boiler is more easily kept free from mud and scale than are those with crown bars, as the crown bars tend to hold the mud and scale against the action of the water to wash them away.

Too much care can not be given to the testing for broken crown bar braces. As they are out of sight and difficult to get at, there is often a tendency to neglect them on the part of those responsible for their being properly tested. Brace pins should also come in for careful inspection.

Hydraulic testing should not always be taken as an indication of a boiler's strength. The test itself may weaken the boiler, so that a similar pressure would cause a giving away of some part of the boiler. The hammer test of staybolts in the hands of an experienced boilermaker is a good staybolt test.

Mud in the water leg will cause bulging and cracking of the sheets, and mud should not be allowed to accumulate there, or, in fact, anywhere else in a boiler.

With the use of soda ash to soften the water, by a frequent use of the automatic blow-off cock a great deal can be done by the engineer to keep the boiler clean. The automatic blow-off cock should not be used when engine is working, as it removes the water from the lower part of the boiler, where there is none too much, anyway, when engine is using steam. At this time the sediment in the boiler is raised up and mixed with the water, and blowing out the boiler does not remove it, as it does when throttle is closed and sediment has settled down in the boiler.

Better results will also be obtained by using the blow-off cock with injectors shut off. Cold water settles to the bottom of the boiler, and if blow-off cock is open it is immediately blown out again.

Scale or mud cause leaks. This calls for frequent calking, and soon the sheet along the crack is worn thin, the head is gone from the staybolt or the bead from the flue, and then calking ceases to do good and the leak is continuous.

Side sheets have been known to blister. This is caused by the sheet not being a solid piece. The side next the fire becoming the hottest, expands toward the fire and leaves the outer part of the sheet, causing a space between the two parts. This is the fault of the metal, caused by its not uniting properly when rolled at the mill.

When an engine is fired up the temperature should be brought up gradually to the required point and then maintained there as near as possible when in service on the road.

A boiler that is inclined to leak should be kept hot all the time when in service, even at the expense of blowing off steam occasionally. The waste even then will not be as great as that caused by a leaky boiler, let alone the annoyance and delay that is almost certain to accrue, with the possibility of an engine failure in addition to all the rest.

The extended wagon-top is now the type of boiler most commonly built. In this form the wagon-top which formerly extended only over the crown sheet, continues on in a diminishing degree, usually to the front ring of the boiler. This gives a much larger dry steam supply to draw from and lessens the danger of an engine working water.

In many new engines a flare is given to the back firebox sheet at the door, which gives a greater water space at that point, and the sheet is overlapped in such a manner as to do away with the old style of door ring. The result has been very satisfactory in doing away with cracks in the door rings and consequent leaks therefrom. The reason the sheets do not crack so readily in the door with increased water space is that they do not cool so quickly under the action of the air when the fire door is opened as they do with the smaller water space.

Holding the fire door open is not very good for either the door ring, flues or the side sheets, and should be avoided. It is better to let the pops take care of the surplus steam than to do this, although that should be avoided also, but in another manner, by keeping down the coal supply to the fire.

Too much care can not be given the boiler of a locomotive to keep it in good shape, and this care should commence when the boiler comes new from the shop, but with the higher steam pressure, larger sheets and longer flues, and the increased tendency to leak from these causes, there has been, as a rule, less care given to them.

Heavy fires form in the firebox because it is hard to clean them on the road; when the terminal is reached the fire is hurriedly cleaned, green coal shoveled in, and away they go with the blower shrieking a forced draft through the flues, clinkering the fire and spoiling the firebox. When a fire is being cleaned or knocked out an injector should not be worked; the firebox will cool fast enough without doing that. If an engine must go right out, knock out all the fire and put in a fresh wood fire, using plenty of wood. It will be cheaper in the long run and an engine failure may be avoided. These look like small matters, but they all count in the life of the boiler.

The pressure applied to a boiler is as a rule only about one-fifth of what it is supposed to be able to stand before bursting; this on account of the plate being weakened by hand-hole plates, wash-out plugs and various boiler connections. But neglect and abuse will soon weaken the best boiler until it is not only a source of trouble on the road, but also becomes a menace to safety. Natural wear and tear is expected, but neglect and abuse should be avoided, which often is the result of orders from those in authority who are ignorant of results or do not care so long as the responsibility falls on some other department or person.

The long flue in the large engine, with its increased vibration over the shorter flue of the small engine, has a greater tendency to cause leaks, as has the larger flue sheet necessary in the large engine. Bracing has helped the large flue sheet, but a satisfactory manner of bracing the long flues has not yet been evolved.

A Repair Shop.

From time to time we have published comprehensive descriptions of large, up-to-date boiler shops, in which the equipment of machinery and tools has been designed for the construction of new boilers and the carrying out of large contracts involving sheet metal and structural steel work. It may be of interest to our readers to know something about the equipment of the boiler department in one of the largest marine repair shops in the country. The equipment of such a shop, of course, does not include so many or such heavy tools as are provided in a contract shop, since repair work involves mainly labor, and requires the handling of less material and lighter weights.

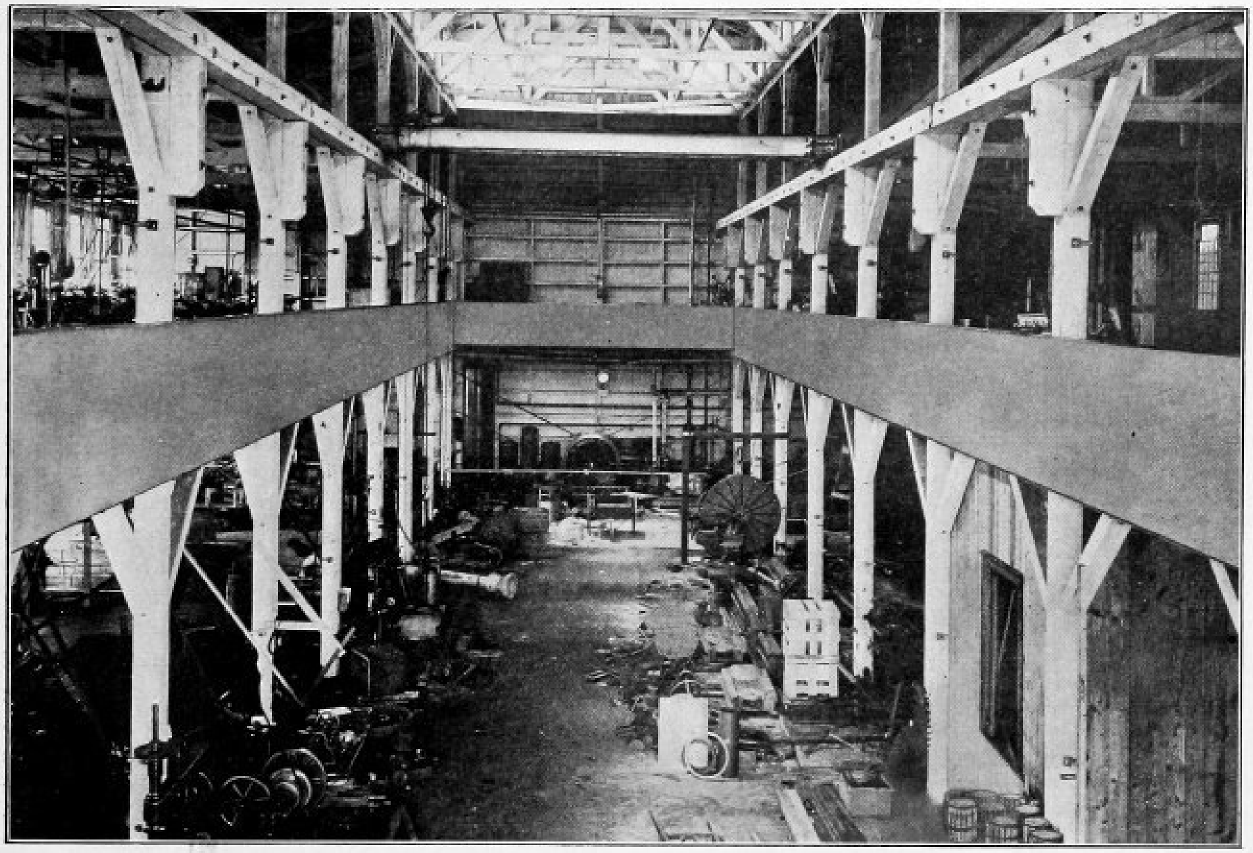
The machine and boiler repair shops of the Griscom-Spencer Company, located on the water front in Jersey City, N. J., are equipped with a view to handling rapidly and economically all types of marine repair work, which are continually coming up in a harbor where the shipping is as extensive as it is in New York. The Griscom-Spencer Company is the direct successor of the late James Reilly Repair & Supply Company, established about forty years ago, and which, in addition to other work of manufacturing and contracting, has for many years provided all the repairs and supplies for the ships of the International Navigation Company, comprising the American and Red Star Lines. The shops and docks are located in Jersey City, adjoining the terminal of the Pennsylvania Railroad. Two spur tracks from this railroad run directly into the yard, one at Grant Street and one at Sussex Street, giving exceptional facilities for transportation or the receiving of supplies. A small industrial track runs through the shops to facilitate the handling of heavy material.

The plant includes the following departments: the machine shop, boiler shop, carpenter, joiner and pattern makers' shop, coppersmith's shop, foundry for heavy brass and composition castings, and an electrical department. The shops have been recently rebuilt and equipped with all the modern facilities for handling, economically and efficiently, repairs, and the manufacture of special machinery. The main shop, of which a photograph is reproduced, contains on the main floor the power plant, tool room and heavy machine tools. In the galleries at either side are located light tools for the brass-finishing department, tinsmiths' shop and electrical department. The floor of this building is served by an electrically-driven traveling crane, spanning the center bay.

Adjoining the main shop, in the form of an ell, is the boiler and forge shop. One side of the boiler shop is left free for laying out, fitting up and bench work. At one end of the shop are located the punches, shears and bending rolls. The equipment of this department includes a small shear of 24 inches gap, built by the Long & Allstatter Company; a small punch, 24 inches gap, built by the same company; a large shear with 27-inch gap, built by the Hilles & Jones Company; a set of 10-foot power bending rolls and a small set of 3-foot hand-power bending rolls. In the center of the shop is a large radial drill and an upright drill-press. Beyond these is a small punch for light material, of the Cockburn-Barrow make. The rest of the shop is devoted to flanging and blacksmith work, and contains, besides the ordinary blacksmith's forges and tools, two sets of heavy flanging clamps and a steam hammer.

The material is handled at the machines in the boiler shop by means of light jib cranes, equipped with chain hoists, capable of lifting about two tons.

All machinery, in both the boiler and machine shops, is belt-driven from overhead line shafting, although plans have been completed for the installation of a system of electrical motor group drive. Power is derived from a single cylinder 75-H. P.



INTERIOR OF MAIN SHOP, JERSEY CITY PLANT OF GRISCOM-SPENCER COMPANY.

Beckett & McDowell steam engine, which has a 10-inch cylinder, 14-inch stroke and runs at the rate of about 150 revolutions per minute. Steam for the engine and air compressors is furnished by one Moran safety water-tube boiler of 150 H. P. Electricity for lighting purposes and for driving some of the machinery in the brass foundry and copper shop is generated by a 15-kilowatt generator. Additional generator capacity is soon to be installed. Duplicate air compressors are installed which deliver compressed air to the pneumatic tools in the boiler shop and at the docks; one of the compressors is a single cylinder Ingersoll-Rand machine with a capacity of 350 cubic feet of air per minute; the other is a duplex Franklin compressor, built by the Chicago Pneumatic Tool Company, capable of delivering 300 cubic feet per minute. The air is stored in two large receiver tanks at a pressure of about 90 pounds per square inch.

In addition to the repair work, the Griscom-Spencer Company manufactures several power plant and marine specialties, among which are the Reilly multicoil feed-water heater, the Reilly multicoil evaporator for both fresh and salt water, the Reilly (Ebsen) grease extractor and feed-water purifier, water filters, condensers, etc.

GENERAL VIEW OF DOCKS AND SHOPS OF THE GRISCOM-SPENCER COMPANY'S JERSEY CITY PLANT.

The Boiler Maker

Published Monthly by

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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.

The edition of this issue of The Boiler Maker comprises 5,500 *copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

Encouraging Signs.

It is hardly necessary to refer to statistics to show the frequency and destructiveness of boiler explosions. These facts are well known, and are being continually emphasized by reports in the daily press. Statistics are of value, however, when it comes to determining the increase or decrease in the number of such accidents and the loss of life resulting from them. For this reason it is of interest to examine such records as are kept, and see if the progress which is being made in the production of better materials, better machinery and methods of construction and the enforcement of more rigid inspection laws, is having any material effect on the safety and reliability of steam boilers.

Perhaps the most carefully compiled statistics on this point are those published by the Hartford Steam Boiler Inspection & Insurance Company. Their annual summary, published elsewhere in this issue, shows that the number of explosions which occurred last year was greater than ever before, and that a life was lost for almost every working day in the year. The number of explosions has steadily increased each year since 1879 from about 130 to nearly 500. There have never been less than 200 people killed, and the number is frequently almost double that. Considered alone these figures show a steady increase in both the number of explosions and the number of fatalities, but considering the vastly greater number of boilers in operation to-day than were in operation a few years ago, it is probable that the ratio of the number of explosions to the number of boilers in use, or the number of explosions per thousand horsepower, is steadily decreasing. This indicates not only that safer boilers are being built and that more rigid inspection is being enforced, but also that boilers are being operated and cared for more intelligently.

During the past year there has been no single explosion which has resulted in such a terrible loss of life as has frequently been the case in previous years. This is probably due partly to the changes made in the design of modern power plants. The old style of wooden factory with the boiler located practically in the building itself is becoming a thing of the past. The centralization of power plants and the distribution of power by electricity has tended to keep the boiler away from crowded factories and buildings. Then, too, the use of mechanical appliances for handling of coal and ash and for stoking, has reduced the number of attendants considerably, so that there is less likelihood of a large list of fatalities in the event of an explosion. It can perhaps hardly be claimed that watertube boilers have insured the safety which was expected of them when they first came into general use, as many destructive explosions have occurred with this type of boiler.

Not only has the opportunity for the destruction of life and property been somewhat lessened, but there has been marked advance in the adoption of adequate boiler inspection laws. It might be said that there are three things which can prevent boiler explosions. The first of these is inspection; the second is inspection; and the third is inspection; inspection of design; inspection of material; inspection of workmanship, and thorough and careful periodic inspection during the use of the boiler after it is completed. New boiler inspection laws have been adopted in several large cities and in one or two States during the past year. For instance, in Massachusetts, a State which has been particularly afflicted with disastrous boiler explosions in years past, a new set of rules governing the construction and installation of boilers has been enforced, which will do much to safeguard the people of that Commonwealth.

A new means of bringing to the attention of power users and the general public the serious fatalities resulting from boiler explosions was also brought about last year by the establishing of a National Museum of Safety Devices in New York City. At the present time this institution is holding an exposition, and in it due importance is given to the steam boiler. Besides numerous photographs showing the results of explosions, there are many samples of bagged, blistered and laminated boiler plates, tubes almost choked with scale, immense pieces of scale taken from the interior of the boilers, samples of pitted and corroded boiler tubes, etc. About the only devices as yet shown which can in any sense be termed safety devices are safety valves, automatic water gages, patent fusible plugs and a description of the merits of certain boiler insurance companies.

Notice.

In order to include a complete report of the proceedings of the annual convention of the International Master Boiler Makers' Association, which is to be held at Detroit, May 26, 27 and 28, the date of publication of our June issue will be changed from the first to the tenth of the month. Besides the report of the convention and the usual amount of editorial matter, this issue will contain a comprehensive supplement of boiler makers' materials, machinery, tools and supplies.

Convention Announcements.

The sessions of the convention of the International Master Boiler Makers' Association will be held May 26, 27 and 28, 1908, at Detroit, Mich., at the Hotel Pontchartrain, which will be headquarters for the association.

The secretary will have an office in the hotel for the transaction of general business outside of the convention.

Immediately upon arrival, each member should report to the secretary for registration of himself and ladies, etc., and receive such instructions as may be of value during the progress of the convention. In this manner confusion and possibly disappointments will be obviated. There will also be assured a correct list of all who attend the convention with their proper home address, and only careful compliance with this arrangement will insure its entire success. Registry cards will be provided, so that if you fail to register there will be no reasonable cause for complaint if your name does not appear in the printed list of the convention proceedings.

Important.—All members of the Boiler Makers' Association must register with Mr. Harry D. Vought, and all members of the Supply Men's Association with Mr. George Slate, in order to receive their badges.

On arriving in Detroit, to reach the hotel, take Brush street car from Brush street station (Lake Shore and Grand Trunk), Woodward avenue car from Michigan Central station and Fort street car from Pere Marquette and Wabash station.

An exceptional opportunity will be offered members of the International Master Boiler Makers' Association who attend the annual convention in Detroit, Mich., to travel via the Michigan Central Railroad.

If a sufficient number elect to use this route from either Chicago or Buffalo they will do so to advantage, as superior service and fares will undoubtedly be offered.

It may be possible for all to travel together and obtain concessions that would not otherwise be available.

Please advise the secretary, Harry D. Vought, 62 Liberty street, New York, at once whether you will attend the convention and whether you wish to be included in whatever arrangements are made.

Program.

MAY 26.

Convention called to order, 10.00 A. M.

Prayer, 10.00 to 10.15 A. M.

Address of welcome by the Mayor, 10.15 to 10.30 A. M.

Address by superintendent of motive power, 10.30 to 11.30 A. M.

Address by superintendent Boiler Manufacturing Company, 11.00 to 11.30 A .M.

Routine business:

Report of secretary.
Report of treasurer.
Appointment of committees.
Miscellaneous.
Announcements.

Unfinished business, 12.00 to 12.15 P. M.

New business, 12.15 to 1.00 P. M.

Appointment of special committees to serve during convention.

Adjournment.

In the afternoon the members of the convention will visit some of the large manufacturing plants in Detroit.

MAY 27.

Report of committee on boiler flues, 9.30 to 10.00 A. M.

Report of committee on boiler explosions, 10.00 to 11.00 A. M.

Topical discussions, 11.00 A. M. to 12.00 M.

RECESS.

Report of the committee on application of stay-bolts, etc., 2.00 to 3.00 P. M.

Report of committee on use of oil in locomotive boiler shops and in boilers, 3.00 to 4.00 P. M.

Topical discussions, 4.00 to 5.00 P. M.

"Shall a Committee be Appointed on Senate?"

"How Shall Committee Reports on Subjects be Brought Before the Convention for Discussion?"

To be opened by Mr. J. H. Smythe.

"Standardizing of Shop Tools."

To be opened by Mr. T. C. Best.

Announcements and adjournment.

MAY 28.

Report of committee on amendments to constitution and by-laws, 9.30 to 10.00 A. M.

Report of committee on subjects, 10.00 to 11.00 A. M.

Topical discussions, 11.00 A. M. to 12.00 M.

"Standardizing Boiler Blue Prints."

To be opened by Mr. W. H. Laughridge.

"Modern Improvements and Physical Tests in Boiler Design and Materials."

To be opened Mr. H. S. Jeffery.

RECESS.

Report of auditing committee, 2.00 to 2.15 P. M.

Miscellaneous business, 2.15 to 2.45 P. M.

Unfinished business, 3.45 to 4.00 P. M.

Correspondence, resolutions, etc., 4.00 to 4.15 P. M.

Selection of next place of meeting, 4.15 to 4.30 P. M.

Good of the association, 4.30 to 5.00 P. M.

Election of officers and closing exercises of convention, 5.30 to 6.00 P. M.

The order of entertainment could not be completed in time to be given in this program and will be announced at Detroit.

COMMITTEES FOR 1907-1908.

1.—Best Method of Applying Flues. Best Method for Caring for Flues while Engine is on the Road and at Terminals and Best Tools for Same. E. J. Hennessy, chairman.

2.—Boiler Explosions; Their Cause and Remedy. J. T. Goodwin, chairman.

3.—The Best Method of Applying Flexible Stay-Bolts; Holding on and Riveting Same. J. H. Smythe, chairman.

4.—The Use of Oil in Locomotive Boiler Shops; the Most Practical Method of Its Use in Stationary and Locomotive Boilers.

5.—Proposed Changes in the Constitution and By-Laws. Charles P. Patrick, chairman.

6.—Subjects: To Recommend Topics for Committee Reports at the Next Annual Convention. William H. Laughridge, chairman.

THE WOMEN'S AUXILIARY.

One of the many excellent features connected with the conventions of the International Master Boiler Makers' Association which should not be forgotten is the Women's Auxiliary. This association, of which Mrs. John McKeown, of Galion, Ohio, is president, and Mrs. James E. Cooke, of Greenville, Pa., secretary, is composed of the wives and daughters of the members. This branch of the organization has always added greatly to the social features of the conventions, and it is urged that all members who intend to be present at the annual convention in Detroit bring their wives and daughters or some near friend, as by so doing they will add materially to the success of the convention. The Women's Auxiliary will meet at the Hotel Pontchartrain on May 28, at 9.30 A. M.

PERSONAL.

MARVIN HOWE has been appointed general foreman of the Oswego shops of the New York Central Railroad, vice C. Youmans, transferred to other duties.

GEORGE WILSON, formerly boiler inspector of the American Locomotive Company at the Schenectady works, has been appointed general supervisor of the boiler department, with jurisdiction over all of the shops of the American Locomotive Company.

SAMUEL E. DUFF, for twelve years manager of the bridge and structural works of the Riter-Conley Manufacturing Company, Pittsburg, has resigned. He will engage in general consulting engineering practice.

JAMES L. MCMANN, proprietor of the Mahoning Boiler Works, Lowellville, Ohio, owing to increased business has purchased property at Struthers, Ohio, and erected a new shop, 36 by 70 feet, where he is better equipped to handle his rapidly growing business.

JOHN P. LEYDEN, formerly with the United States Cast Iron Pipe & Foundry Company, has assumed the duties of general master mechanic of the Dimmick Pipe Works, Birmingham, Ala.

N. T. MCKEE, formerly foreman of the L. S. & M. S. Railway locomotive shops at Collinwood, Ohio, has entered the firm of H. Clay McKee & Sons Company, at Mount Sterling, Ky., as partner.

THE PLANT of the Waley Boiler Works, Providence, R. I., was recently completely destroyed by fire.

WILLIAM NORTON, proprietor of the Puget Sound Boiler Works, Tacoma, Wash., died Feb. 24 at Puyallup, Wash. Mr. Norton was on his way to Chicago when taken ill with heart disease, and was taken from the train at the above-named town, his death occurring shortly afterward. Mr. Norton was well known on the coast and to boiler manufacturers throughout the country, and his sudden death came as a severe shock to his many friends. He was formerly connected with the Willamette Boiler Works, Portland, leaving them eighteen years ago to form the company of which he was proprietor until his death.

THOMAS WOOD, formerly for three years layer-out for the McIlvain & Spiegel Boiler Company, of Cincinnati, Ohio, has recently taken charge of a new boiler shop at Matanzas, Cuba, for the Ansonia Copper & Sheet Iron Works of Cincinnati, Ohio. Mr. Wood assumed his new duties on the first of last October, and has already completed three 90-foot, one 40-foot, one 60-foot and two 20-foot tanks, besides some small 14-foot and 16-foot tanks. The establishing of this boiler shop by the Ansonia Copper & Sheet Iron Works was the result of a contract which this concern secured for erecting a distillery for the Cuba Distilling Company, which includes a steel building six stories high, 410 feet long, 92½ feet wide, a steel self-supporting stack 125 feet high, eight tanks 90 feet in diameter and 30 feet high, one 60-foot tank 28 feet high, two 40-foot tanks 22 feet high, and three 20-foot tanks 20 feet high. All of these tanks are for molasses and are built with steel roofs. In addition to the above work there are a great many small tanks scattered through the distillery to be constructed. The duty on finished products is so heavy in Cuba that a strictly modern boiler shop was built and equipped so that all the steel work on the contract could be worked up on the spot. The shop which was constructed to carry out this work is 100 feet long, 50 feet wide, with a side bay for a machine shop and also a blacksmith shop 40 feet long by 20 feet wide.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS is extending the scope of its published proceedings by issuing a regular monthly periodical. This publication is to have a recognized and responsible editor, in the selection of whom the society is to be heartily congratulated. Mr. Lester G. French, formerly editor of *Machinery*, has been appointed, and has already entered upon his duties.

In 1891 Mr. French received his degree in mechanical engineering from the Massachusetts Institute of Technology. After four years' apprenticeship, drafting room and shop experience, principally at the Builders' Iron Foundry shops in Providence, and a year and a half as a text-book writer, Mr. French was engaged on the editorial staff of *Machinery*, and assisted greatly in the development of that paper, and for nine years was its editor-in-chief.

Among the immediate improvements to be undertaken is the establishing of departments in the monthly *Proceedings*, thus providing a greater variety of technical articles of interest. Many other features are planned, and the aim will be to make the *Proceedings* of such value that no engineer can afford to be without them.

IT is pleasant to reflect that even in the stress of business and the cares and worries of a busy railroad shop, there can be born in the hearts of men, not only genuine respect, but even affection for the man under whom they serve. We are reminded that such feelings do exist by the observance of the sixty-sixth anniversary of the birth of Mr. Morris Davis, foreman of the boiler department of the Pennsylvania Railroad, Altoona machine shops, which was celebrated on Jan. 28 by his family and a number of his friends who have been associated with him in his work for many years. The guests assembled early in the evening, and after an excellent dinner, passed a pleasant hour in conversation, reminiscence and impromptu remarks. The following well-known shopmen were present: R. J. McKerihan and S. B. Kinch, of the Juniata boiler shops; J. B. Tate, H. G. Greene and J. F. Stahl, of the boiler department of the Altoona machine shops; also John McKerihan, of miscellaneous shops, and Rev. H. L. Bowlby, pastor of the First Presbyterian Church, of Altoona. Several of the gentlemen present made short addresses, expressing appreciation of having had the privilege of training received under Mr. Davis, and of the association with him for many years. Excellent testimony was borne to his exemplary character as a Christian gentleman. Also he was the recipient of a number of handsome presents. The photograph showing Mr. Davis sitting in his library will be recognized by many boiler makers and railroad men throughout the country, as he

MORRIS DAVIS.

is a recognized authority on boiler work and is very well known, having entered the boiler department at the Altoona shops Sept. 5, 1859, at which place he has been continuously in service ever since, with the exception of three years, from 1862 to 1865, when he served in the Union Army, being mustered out with the rank of Captain. He was made assistant foreman of the boiler shop in January, 1877, and foreman in December, 1896.

TECHNICAL PUBLICATIONS.

Mensuration for Sheet Metal Workers. By William Neubecker. Size, 5½ by 7½ inches. Pages, 51. Illustrations, 70. David Williams Company, 14 Park Place, New York City. Price, 50 cents.

The subject matter in this little volume has been reprinted from recent issues of the *Metal Worker, Plumber and Steam Fitter*. The author has evidently realized that in order to make rules, formulæ and tables of any use to an ordinary workman in the shop they must be accompanied by clear explanations and examples. Therefore, these articles were written so that such rules, which are not generally explained, can be easily understood, enabling one to proceed intelligently with practical problems which come up. Examples in computing the perimeters, areas and capacities for various shapes arising in practice are given in detail. It is expected that comprehension of these will enable the student to compute any ordinary problem in the shop. Besides methods for finding the length, areas and volumes of the simpler geometrical forms, examples are given in computing the areas of heating and ventilating pipes of all ordinary shapes, making their areas equal to those of pipe of other profiles. The use of the prismoidal formulæ for obtaining the capacity of various shaped bodies is fully explained, as is the method of obtaining the height of any solid to hold a given quantity when the diameter is known, or vice versa. A short rule is illustrated for finding the diameter of branch pipes taken from a given main pipe, so that the areas of the branches will equal the area of the main. In general the class of problems treated is such as have to do with construction of very light sheet metal work, such as chimney tops, pipe work, small tanks and domestic articles, rather than heavy plate or boiler work.

Washing and Coking Tests of Coal and Cupola Tests of Coke. By Richard Moldenke, A. W. Belden and G. R. Delamater. Size, 5¾ by 9 inches. Pages, 76. Bulletin No. 336. Department of Interior, United States Geological Survey, Washington, D. C.

This pamphlet comprises a report of tests which were made during the fiscal years 1905 and 1906 at the St. Louis fuel-testing laboratories of the United States Geological Survey, on washing and coking coals and on the behavior of the resulting coke in cupola practice. These tests were carried on in connection with similar investigations of the steaming and gas-producing qualities of the same coals and of the possibility of improving such coals by briquetting.

Many coals which were received as samples from the mine were found to be too high in ash, in sulphur or in phosphorus to make a satisfactory metallurgical coke without prior treatment, and some coals possessed better coking qualities than others. It was found that the washing of some coals so reduced the percentage of ash and sulphur as to make available for the production of coke a coal which otherwise would have had no value for this purpose. Complete details are given in the bulletin regarding washing of coal, the production of coke therefrom and the behavior of the coke in the cupola when utilized for the production of castings. The results have all been carefully tabulated, so that a study of the tables shows at once many important facts as to the behavior and the treatment of the coals mined in various portions of the United States when prepared as metallurgical coke.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Will you please publish in THE BOILER MAKER a practical and accurate method for laying out a spherical roof for a tank of any diameter. F. O.

A.—See the article "Layout of a Hemispherical Tank Head," page 74, March, 1908, issue of THE BOILER MAKER.

If "F. O." will send us his name and address, we shall be glad to answer his question more specifically.

Q.—Will you please show me how to figure out the size and spacing of rivet holes on a patch 6 feet long and 4 feet wide on the fire sheet of a horizontal tubular boiler 72 inches in diameter; ½ inch plate; steam pressure 100 pounds; efficiency of seams 80 percent; factor of safety 6; tensile strength of plate 60,000 pounds per square inch? "E."

A.—If "E." will send us his name and address, we shall be glad to answer his question.

Q.—Can you give me an idea of the character of work done with pneumatic riveting hammers driving ⅞-inch rivets in ½-inch sheets in the shells of steam boilers carrying 125 pounds pressure? Do they always fill the holes and make good steam-tight work? If so, what size hammers are generally used for this size of rivet? We have tried a 6-inch stroke hammer, but it did not fill the holes properly. H. A. F.

A.—The work you describe is done every day and very satisfactorily, too, in many shops, but a 6-inch stroke hammer is not the proper size, as it will not develop sufficient power. We would recommend a hammer which has a piston diameter of 1⅛-inch by 9-inch stroke, and if operated under an air pressure of from 80 to 100 pounds per square inch, we are sure ⅞-inch rivets can be driven steam-tight. D. P. T. Co.

If you have an air pressure of from 90 to 100 pounds per square inch, and the rivets are properly heated their entire length, using a pneumatic hammer having a piston 1 3/16 inches diameter and 8-inch stroke should make absolutely tight work, filling the holes as well as it is possible to fill them under any other system of riveting.

We note you say you have tried a 6-inch stroke hammer. While a 6-inch stroke hammer is used very extensively for structural work, we would not recommend a 6-inch stroke hammer for driving steam-tight work on rivets larger than ½ inch. You are doubtless aware that a pneumatic riveting hammer may show very satisfactory results driving rivets on structural work and yet fail to make steam-tight work on boiler work. A little experimenting will show that the degree to which the rivet is staved in the hole depends very largely upon the weight of the striking piston. While in the ordinary hand riveter for structural work the piston is 1 1/16 inches in diameter, a class of riveters with pistons 1 3/16 inches in diameter is, by virtue of the heavier piston, particularly adapted to steam-tight work. P. P. T. Co.

Q.—In a 6-foot cylinder, built of five courses of ½-inch plate, with single-riveted lap joints, how much allowance is made in the length of the plates for the inside and outside courses, aside from the apparent difference in the size of the courses, so that the several courses may be assembled with the holes fairly in line; 72 inches is the mean diameter; that is the inside diameter of one course and the outside diameter of the other. Is there any rule for this fitting up allowance? LAYER OUT.

A.—There is no definite rule for the "fitting up" allowance to which you refer. The amount to be allowed depends entirely upon the class of work which is being done. In work which is not to be steam tight, or to withstand very much pressure, a fairly large allowance can be made so that the work may be fitted up easily and quickly, although the joint may not be a tight fit. In other cases very little allowance is made and great care is taken to shear and punch the plates exactly to size.

It is a common practice to make the difference in length of an inside and outside course either 6¼, 6½ or 7 times the thickness of the plate. It can be seen from a consideration of Fig. 1 just how much allowance this really gives. In Fig. 1 the mean diameter is 72 inches. The diameter at the center of the inside course is 72 inches, minus the thickness of plate (½ inch). The circumference corresponding to this diameter is 3.1416 × (72 — ½), or 3.1416 × 72 — 3.1416 × ½. The diameter at the center of the outside course is 72 inches + ½ inch. The circumference corresponding to this diameter is 3.1416 × (72 + ½), or 3.1416 × 72 + 3.1416 × ½. Therefore, the difference in length between the circumference of

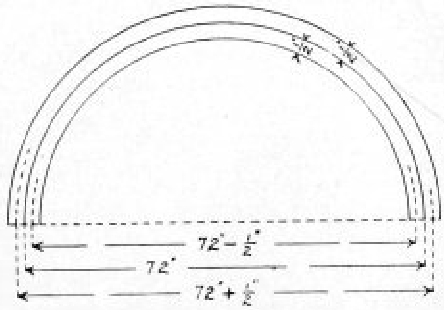


FIG. 1.

the outside course and the inside course is 3.1416 × 72 + 3.1416 × ½ — (3.1416 × 72 — 3.1416 × ½) = 3.1416 × 72 + 3.1416 × ½ — 3.1416 × 72 + 3.1416 × ½ = ½ × (3.1416 + 3.1416) = ½ × 6.2832, or 6.2832 times thickness of the plate. Therefore, it will be seen that the actual difference in size between the length of the inner and outer courses is slightly over 6¼ times the thickness of plate. If 6½ times the thickness of the plate is used it will make a tight fit, whereas if seven × thickness of the plate is used it will give a moderately easy fit. It is seldom that more allowance than this is made.

Of course, although the two sheets are of different lengths the number of rivet holes in the seams must be the same. That is, the same number of spaces must be stepped off on the seam of the inner sheet as on the outer, although the spaces on the outer sheet will be slightly larger than those on the inner sheet. This will make the holes come fair when the sheets are rolled up and fitted together.

Q.—In a locomotive boiler with a flat crown sheet 5 feet 9¾ inches long, 39 inches wide and ⅜ inch thick, how many and what size crown bars must be used to withstand a pressure of 150 pounds per square inch? The height of the bar is restricted by the dry pipe leading up into the dome, which is directly in line over the crown sheet. The height from the top of the crown sheet to the bottom of the dry pipe is 8 inches. Will it be necessary to use sling stays on each crown bar, or will the bars which you specify carry the steam pressure without any assistance from the shell of the boiler? P. F. G.

A.—Answering the latter part of the question first, that is, as to whether the crown bars will need to be supported by sling stays to the shell of the boiler, this is a matter which is entirely at the disposition of the designer. He may design a crown bar sufficiently strong to carry the entire pressure, or he may use a lighter bar and support it with sling stays from the shell. If the design is carried through, and it is found that without using sling stays the bars will be exceptionally large and heavy, it would be better to use sling stays and reduce the size of the bar, but if there is sufficient space over the crown sheet to use a well-proportioned crown bar which will be strong enough to withstand the pressure without additional staying, it might be considered desirable to do so.

First, carry through the design for a crown bar which is not to be supported by sling stays. If it is found that there is not room over the crown sheet to use such a bar, then the design may be modified and sling stays used.

The first thing to determine is the pitch of bolts which can be used in the crown sheet. This will depend upon the thickness of the sheet and the steam pressure in the boiler, which are ⅜ inch and 150 pounds, respectively. The pitch can be determined from the following formula:

$$p^2 = \frac{115 \times t^2}{P}$$

where p = pitch of bolts in inches.
t = thickness of crown sheet in sixteenths of an inch.
P = working pressure in pounds per square inch.

Substituting the values in the above formula we have

$$p^2 = \frac{115 \times 6^2}{150}$$

$$p^2 = 27.6.$$

$$p = 5¼ \text{ inches.}$$

Since the bolts in the crown sheet cannot be spaced at a pitch greater than 5¼ inches, we can now determine the number of crown bars which must be used, since they must be spaced not more than 5¼ inches apart. Total length of the crown sheet is 5 feet 9¾ inches, or 69¾ inches. Dividing this by 5¼ we find that there are 13.3 spaces. We must, therefore, use 13 crown bars and 14 spaces, making the distance center to center of bars 5 inches.

The constant used in the above formula is slightly larger than is specified in the United States Rules. For plates 7/16 inch thick and under the constant 112 is usually used. This would give the pitch as 5 3/16 inches instead of 5¼ inches.

In every bar there must be seven bolts spaced approximately 5 inches apart. This gives an area of 5 × 5, or 25 square inches of crown sheet to be supported by each bolt. At 150 pounds pressure the load on each bolt will therefore be 25 × 150 = 3,750 pounds. Considering the crown bar as a girder loaded, as shown in Fig. 1, the seven bolts each with a load of

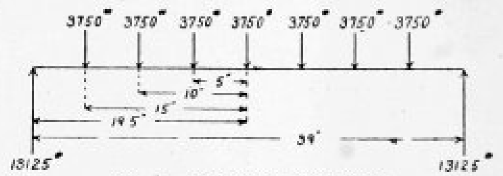


FIG. 1.—LOADING OF CROWN BAR.

3,750 pounds, the total load on each crown bar will be 3,750 × 7 = 26,250 pounds. One-half of this load will be supported at each end of the bar; that is, the supporting force at each end of the bar will be 13,125 pounds.

We must now find the maximum stress in the bar. This will occur at the center of the bar. Therefore, the bending moment M at the center section will be as follows:

$$M = 13{,}125 \times 19.5 - 3{,}750 \ (15 + 10 + 5).$$

$$M = 255{,}938 - 112{,}500.$$

$$M = 143{,}438.$$

The formula for the strength of a beam is

$$f = \frac{M \times y}{I}$$

where f = the allowable unit stress in the material.
M = the bending moment at the most strained section of the bar.
y = the distance from the neutral axis or center of the bar to the most strained fibre.
I = the moment of inertia of a cross-section of the bar at its most strained section about its neutral axis.

The values to be used in the above formula are as follows: f may be taken as 10,000 pounds; that is, a stress of 10,000 pounds per square inch may be allowed in the material. This is equivalent to using a factor of safety of 6 with material, which has a tensile strength of 60,000 pounds per square inch. M has just been found to be 143,438. y is the distance from the center to the edge of the bar; that is, one-half the depth. This is the quantity which we wish to determine, and therefore the equation will be solved for the quantity y. $I = 1/12 \times$ the thickness of the girder $\times$ (the depth of the girder)^3. We will assume that each crown bar is made up of two plates, each 1 inch thick. Therefore, the thickness of the girder will be 2 inches. The depth is the quantity which we wish to determine, and which for the present is designated as $2y$. Our formula then becomes

$$10{,}000 = \frac{143{,}438 \times y}{1/12 \times 2 \times (2y)^3}$$

$$10{,}000 = \frac{12 \times 143{,}438}{2 \times 8 \times y^2}$$

$$y^2 = \frac{12 \times 143{,}438}{2 \times 8 \times 10{,}000}$$

$$y^2 = 10.75785.$$

$$y = 3.28 \text{ inches.}$$

y is one-half the depth of the girder, therefore the depth of the girder will be 6.56, or 6 9/16 inches.

Therefore the crown sheet will be braced to withstand 150 pounds steam pressure if thirteen girders are used, each of which consists of two bars 1 inch thick and 6 9/16 inches deep. As there is 8 inches clear space above the crown sheet, bars of this size can be used, and it will be unnecessary to use sling stays.

Some may consider that the value for unit stress in the material taken in the above problem, which is equivalent to using a factor of safety of 6, is too high. The Hartford Steam Boiler Insurance Company prescribe a factor of safety of 10, which would make the unit stress 6,000 pounds. Using this value, the depth of the girder figures out at about 8½ inches. Therefore, if this value should be used it would be necessary, on account of the limited space above the crown sheet, to use sling stays with the crown bars.

Q.—1. How do you find the pitch of stays on locomotive boilers?
Q.—2. How do you find the pitch of stays on vertical boilers?
Q.—3. How do you figure a butt strap joint?
Q.—4. How do you find the pitch of rivets on a butt strap joint?
Q.—5. How do you find the area of the segment of a boiler head to be braced on a return tubular boiler?
Q.—6. How do you find the number of braces necessary for the segment mentioned in the preceding question? C. H. T.

A.—1. The pitch of stays in the fire-box of a locomotive boiler or on any other flat surface subjected to a uniformly distributed pressure depends upon the thickness of the plate and the working pressure.

Assuming that we have a locomotive boiler carrying 200 pounds steam pressure, the fire-box side sheets being ⅜ inch thick, then the pitch of stays will be found as follows:

$$p^2 = \frac{115 \times t^2}{P}$$

where p = pitch in inches.
t = thickness of plate in sixteenths of an inch.
P = working pressure in pounds per square inch.

Substituting the values assumed above:

$$p^2 = \frac{115 \times 6^2}{200}$$

$$p^2 = 20.7.$$

$$p = 4.55.$$

This is slightly over 4½ inches, therefore the pitch should be approximately 4½ inches.

The formula given above is one of many which are used to determine the pressure on a stayed flat surface. Nearly all of these formulæ are of the same general type, but differ in the matter of the constants used. The constant 115 used in the above formula is well suited to the thickness of plate assumed in this problem, and gives results which accord well with general practice.

2. In a vertical boiler the fire-box is circular, and therefore on account of its shape tends to resist external fluid pressure without any staying. It is advantageous, however, to make the fire-box wall as thin as possible, in order that the transfer of heat from the fire to the water in the boiler may be rapid. Since the fire-box, then, is a cylinder of large diameter with very thin walls, it is not safe to depend on its cylindrical shape to carry much of the pressure. It will carry some, however, and due to this fact the pitch of stays may be made larger than in the case of a perfectly flat plate, such as is used in a locomotive boiler. Assuming a vertical boiler with a fire-box 30 inches in diameter, 32 inches high, of 5/16-inch plate, and a steam pressure of 170 pounds per square inch, we can figure out the collapsing pressure:

$$P = \frac{\text{constant} \times t^2}{d \times \sqrt{L}}$$

where the constant is taken as 600 for iron and 660 for steel.

t = thickness of the plate in 32nds of an inch.
d = diameter of furnace in inches.
L = length of furnace in inches.

Substituting values in the above formula we have

$$P = \frac{660 \times 10^2}{30 \times \sqrt{32}}$$

$$P = 390 \text{ pounds per square inch.}$$

If 390 pounds is the collapsing pressure of the furnace without any stays we may consider that the furnace will safely withstand one-sixth of this pressure, or 65 pounds, without the aid of stays. This is equivalent to using a factor of safety of 6. Subtracting 65 from 170, we have left 105 pounds per square inch, which must be taken care of by the stays. Substituting in the formula given in the preceding question for the pitch of stays, we have

$$p^2 = \frac{115 \times 5^2}{105}$$

$$p^2 = 27.40.$$

$$p = 5.23, \text{ or } 5\tfrac{1}{4} \text{ inches.}$$

It will be seen, therefore, that the pitch of stays for a circular furnace in a vertical boiler is somewhat greater than would be allowed on a plain, flat surface.

3. Assume a triple-riveted butt joint with inside and outside cover plates, as shown in the illustration. Dimensions of the joint are as follows:

Thickness of plate 7/16, or .437 inch.

Diameter of rivet (when driven) 15/16, or .938 inch.

p, Pitch of inner row of rivets 3⅝, or 3.625 inches.

P, pitch of outer row of rivets 7¼, or 7.25 inches.

Tensile strength of plate, 60,000 pounds per square inch.

Shearing strength of rivets in single shear, 45,000 pounds per square inch.

Shearing strength of rivets in double shear, 88,000 pounds per square inch.

Crushing strength of plate, 95,000 pounds per square inch.

The two inner rows of rivets are staggered and extend through both cover straps. In the outer row the rivets are spaced twice as far apart as in the inner row and extend only through the inner cover strap. The strength of the joint is determined by finding the resistance to the different possible modes of failure of a section of the joint, which has a length equal to one pitch of rivets. The ratio of the least resistance thus found to the strength of a section of the solid plate for the same length is the efficiency of the joint.

The joint may fail first by tearing the plate at the outer row of rivets. The strength of the joint to resist such failure is as follows:

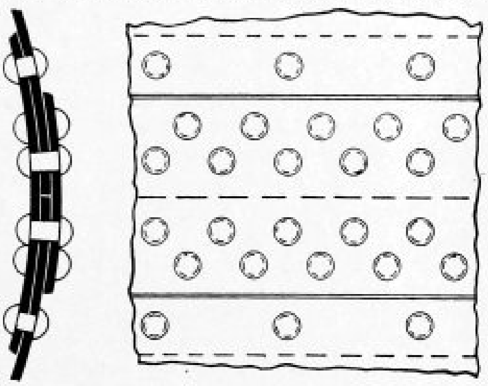
(Greatest pitch of rivets — diameter of one rivet) $\times$ tensile strength of plate $\times$ thickness of plate $= (7.25 - .938) \times 60{,}000 \times .437 = 165{,}400$ pounds .... I.

The joint may fail by tearing the plate at the inner row of rivets and shearing the outer row. The resistance to this mode of failure is

(Greatest pitch $- 2 \times$ diameter of one rivet) $\times$ tensile strength of plate $\times$ thickness of plate $+$ area one rivet $\times$ shearing strength in single shear $= (7.25 - 2 \times .938) \times$

$$60{,}000 \times .437 + \frac{3.1416 \times (.938)^2}{4} \times 45{,}000 = 141{,}000 + 31{,}100 = 172{,}100 \text{ pounds} \ldots\ldots \text{II.}$$

The third mode of failure is by shearing all the rivets, those in the outer row being in single shear and those in the inner



TRIPLE RIVETED BUTT JOINT.

rows in double shear. The resistance to this mode of failure is as follows:

Area one rivet $\times$ shearing strength in single shear $+$ area four rivets $\times$ shearing strength in double shear $=$

$$\frac{3.1416 \times (.938)^2}{4} \times (45{,}000 + 4 \times 88{,}000) = 274{,}200$$

pounds .... III.

The joint may also fail by crushing the plate in front of the rivets in the inner row and shearing the rivets in the outer row. The resistance to this mode of failure is as follows:

$4 \times$ diameter of one rivet $\times$ thickness of plate $\times$ the crushing strength of the material $+$ area of one rivet $\times$ the shearing strength of plate $= 4 \times .938 \times .437 \times 95{,}000 +$

$$\frac{3.1416 \times (.938)^2}{4} \times 45{,}000 = 155{,}800 + 31{,}100 = 186{,}900$$

pounds .... IV.

It will be seen that the resistance to the first mode of failure, that is, tearing the plate at the outer row of rivets, is the least value obtained. Therefore, this determines the strength of the joint. The strength of the solid plate for a length of one pitch is $60{,}000 \times 7.25 \times .437 = 190{,}000$. Therefore, the

$$\text{strength of the joint is } \frac{165{,}400 \times 100}{190{,}000} = 87 \text{ percent.}$$

4. The pitch of rivets in a butt strap joint is determined partly by proportioning the joint so that the combination of diameter of rivets, pitch of rivets and thickness of plate will give the highest efficiency possible with that type of joint and partly by practical considerations, such as allowing sufficient space between the rivets, so that the dies on the machine will not destroy the rivet heads, or placing the rivets near enough together so that the joint can be calked.

If the pitch were determined according to theoretical considerations in the joint described in question 3, the idea in the design would be to make the resistance of the joint to tearing at the inner row of rivets (where the pitch is small), plus the shearing of the outer row of rivets greater than the resistance to tearing at the outer row of rivets (where the pitch is larger). This can be accomplished by equating the resistance to tearing at the outer row of rivets to the resistance to tearing at the inner row, plus the resistance to shearing at the outer row. This gives an equation from which the diameter of the rivet can be determined. Having determined the diameter of rivet the pitch may be determined either by equating the resistance to tearing at the outer row of rivets to the resistance to shearing of three rivets or to the resistance to crushing in front of three rivets, or to the resistance to tearing between the inner row of rivets and crushing before the outer rivet. The smallest pitch thus obtained will be the correct one to use with this diameter.

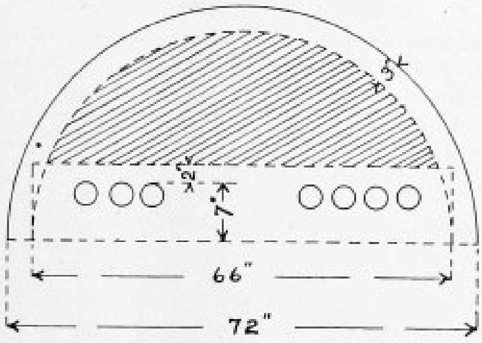
Instead of going through the rather complicated calculations just indicated, it is perhaps easier to make use of a table showing ordinary proportions of diameter and pitch of rivets for this type of joint, and then modify the design if necessary for practical considerations, or if these proportions do not give a satisfactory efficiency of joint. Such a table is given below, the pitch being the minimum pitch, or the pitch of rivets in the inside row. If a triple-riveted butt joint is used, as was the case in question 2, the pitch of rivets in the outer row would, of course, be twice that given in the table:

Kind of Riveting.	Plate.	Rivet.	Hole.	Pitch.
Double Riveting.	3/16	1/2	17/32	1 7/8
	1/4	5/8	11/16	2 1/2
	9/32	11/16	3/4	2 3/4
	5/16	11/16	3/4	2 9/16
	3/8	3/4	13/16	2 9/16
	7/16	7/8	15/16	2 15/16
	1/2	1	1 1/16	3 5/16
	9/16	1	1 1/16	3 1/16
	5/8	1	1 1/16	2 7/8
	11/16	1 1/8	1 3/16	3 1/4
	3/4	1 1/8	1 3/16	3 1/16
	13/16	1 1/8	1 3/16	2 15/16
	7/8	1 1/8	1 3/16	2 13/16
	15/16	1 1/4	1 5/16	3 1/4
	1	1 1/4	1 5/16	3

Kind of Riveting.	Plate.	Rivet.	Hole.	Pitch.
Triple Riveting.	1/4	5/8	11/16	3
	9/32	11/16	3/4	3 1/8
	5/16	11/16	3/4	3 1/8
	3/8	3/4	13/16	3 1/4
	7/16	7/8	15/16	3 3/4
	1/2	1	1 1/16	4 1/4
	9/16	1	1 1/16	4 1/8
	5/8	1	1 1/16	3 3/4
	11/16	1 1/8	1 3/16	4 1/4
	3/4	1 1/8	1 3/16	4
	13/16	1 1/8	1 3/16	3 3/4
	7/8	1 1/8	1 3/16	3 5/8
	15/16	1 1/4	1 5/16	4 1/16
	1	1 1/4	1 5/16	3 7/8

5. The area of the segment of a boiler head to be braced in a return tubular boiler can be determined by finding the area of the entire semi-circle and subtracting from this the area of a rectangle whose length is the diameter of the circle, and whose width is the radius of the semi-circle minus the height of the segment.

The diagram shows what part of boiler head must be figured as area to be braced. It is considered that the flange at the edge of the head securely braces a strip 3 inches wide around the head, and also that the upper row of tubes securely braces a strip 2 inches wide above the tubes. Therefore, in the case of a 72-inch boiler, as shown in the drawing, with the top of the upper row of tubes 7 inches above the center line of the boiler, we have to find the area of the segment of a circle $72 - (2 \times 3) = 66$ inches in diameter. The area of a circle 66 inches in diameter is $\frac{3.1416 \times (66)^2}{4} = 3421.2$ square inches. One-half of this, or the area of the semi-circle, is 1710.6 square inches. Subtract from this area the area of the



SHADED PORTION SHOWS AREA OF SEGMENT TO BE BRACED.

rectangular portion shown in the figure, whose length is 66 inches and whose width is $7 + 2$, or 9 inches. $66 \times 9 = 594$. $1710.6 - 594 = 1116.6$ square inches, area of segment.

This area is slightly smaller than the actual area of the segment to be braced. The exact amount by which they differ is the area of the two small triangular sections at each end of the rectangular strip.

6. If the steam pressure in the boiler, the area of whose segment has just been computed in the preceding question, is 100 pounds per square inch, the number of braces necessary will be found as follows: The area of the segment × working pressure in pounds per square inch = number of braces × area of one brace × allowable unit stress on the braces.

Assuming that the braces used are 1¼ inches in diameter, and are allowed 6,000 pounds per square inch tensile stress, the number of braces required in the above boiler will be as follows:

$$1117 \times 100 = \text{number of braces} \times \frac{3.1416 \times (1.25)^2}{4} \times 6{,}000.$$

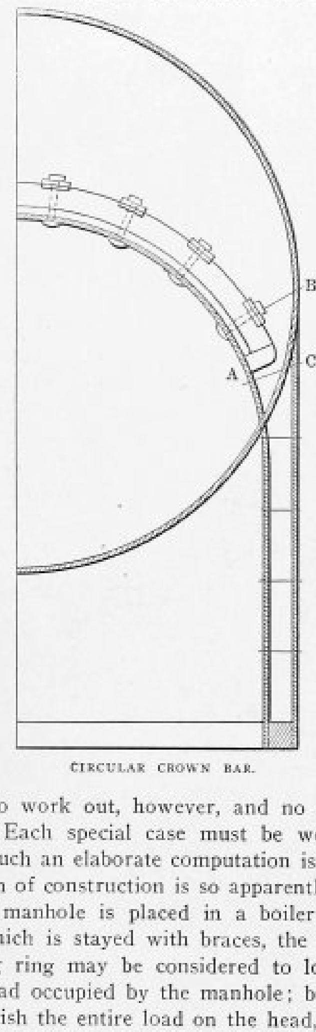
Number of braces = 14½. Therefore, fifteen braces 1¼ inches in diameter must be used.

Q. 1.—How do you figure the size of a crown bar for a circular crown sheet similar to the one shown in the sketch?

Q. 2.—What allowance is made when a manhole is placed either above or below the tubes in a boiler head, as in those cases some of the braces are usually omitted? S. M. G.

A.—The use of a circular crown bar, such as is shown in your sketch, is not practical, because nearly the whole load, due to the steam pressure on the crown sheet, must be supported by the thin crown sheet itself at the point *A*. If the bar simply rests against the sheet at this point, and is free to slide upon it, one component of this force will be normal to the sheet and the other tangential to it. If, however, the bar is supported in a vertical direction at this point, an even greater load will be brought upon the sheet, since that portion of the load which in the first case simply produced a tensile stress in the bar is now supported by the crown sheet. It is not only impractical to concentrate such a heavy load at a single point on the thin plate, but even if the plate would stand it, the stays marked *B* and *C* would be excessively strained. The only form of fire-box with which it is practical to use a crown bar is one on which the crown sheet is flat, so that the loads will all act in a vertical direction and the bar can be supported upon the side sheets of the fire-box.

If this construction were practical, the question of whether the curved crown bar would be stronger than a flat one, or not, would depend entirely on whether the ends of the bar were capable of movement in a horizontal direction, or whether they were absolutely fixed. In the first case the bar would be no stronger than the ordinary flat bar, but would probably be slightly weaker, since there is an added thrust along the length of the bar. If, however, all horizontal movement of the supports can be prevented, then the bar may be treated as an arched rib, and will be stronger than a flat beam. This is a



CIRCULAR CROWN BAR.

difficult case to work out, however, and no formula can be given for it. Each special case must be worked out individually, and such an elaborate computation is hardly justified where the form of construction is so apparently impracticable.

2. Where a manhole is placed in a boiler head or other flat surface which is stayed with braces, the flanged hole or the reinforcing ring may be considered to locally brace the area of the head occupied by the manhole; but it, of course, does not diminish the entire load on the head, since the same area is submitted to the steam pressure whether there is a manhole there or not, and, although the manhole strengthens the plate locally, it itself is not supported in any way, and, therefore, the area of braces used in the head should be the same in both cases. As it may perhaps be impossible to use as many braces in the head on account of the space taken up by the manhole, the area of the braces should be increased, so that they will support the entire load, and the braces should be spaced as equally as possible around the manhole.

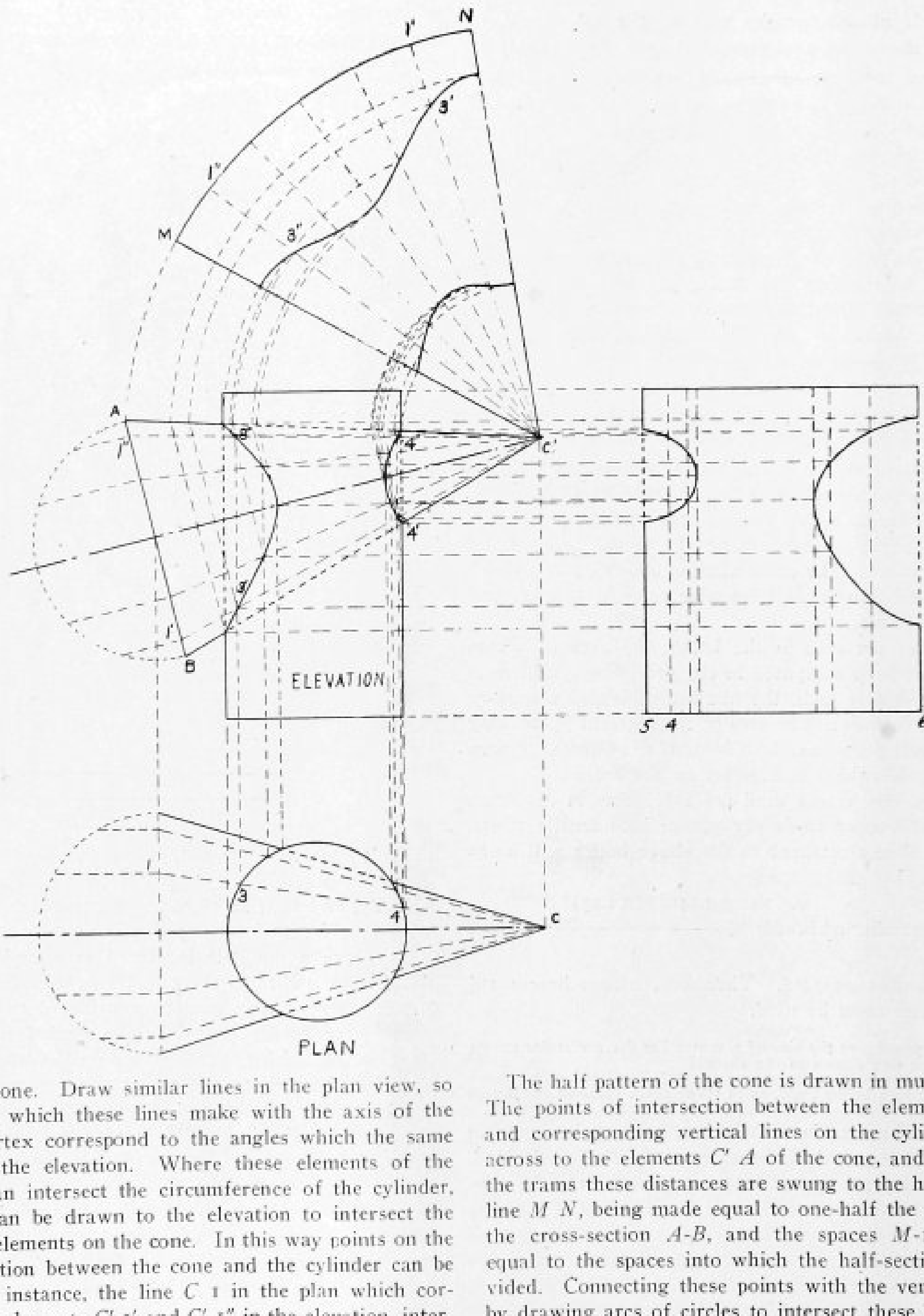
Q. 1.—How do you develop the intersection of a cylinder and cone when their axes intersect at an angle other than a right angle?

Q. 2.—Is it necessary for a boiler inspector of the U. S. merchant marine to have marine sea experience? J. B. R.

A.—1. In the diagram the plan and elevation of a cone intersecting a cylinder are shown, and also the development of the half pattern of both the cone and cylinder.

In order to attack a problem of this sort the work becomes much easier after the student has mastered the principles of descriptive geometry; but since this work is not generally understood, the following practical explanation may serve to show how the problem can be solved. In the first place, in the elevation, which lie upon the line of intersection of the cone *A-B*. This will be a circle, and, therefore, draw a half plan of it and divide the circumference into any number of equal parts. Project these points of division to the line *A-B*, and from the line *A-B* draw lines to the vertex of the cone *C'*. The lines so drawn may be considered as the intersections with the surface of a number of vertical planes passing through the drawn in as a smooth curve, shown by the black line in the elevation.

Turning now to the half pattern of the cylinder, the line 5-6 is laid out equal in length to one-half the circumference of the cylinder, and then, beginning from 5, the spaces as measured on the circumference in the plan are laid off and vertical lines drawn similar to those in the elevation. The points which have been located on these vertical lines in the elevation, which lie upon the line of intersection of the cone and cylinder, are then projected across to the corresponding vertical lines on the half pattern, locating the lines of intersection as they will appear with the cylinder rolled out flat.



vertex of the cone. Draw similar lines in the plan view, so that the angles which these lines make with the axis of the cone at the vertex correspond to the angles which the same lines made in the elevation. Where these elements of the cone in the plan intersect the circumference of the cylinder, vertical lines can be drawn to the elevation to intersect the corresponding elements on the cone. In this way points on the line of intersection between the cone and the cylinder can be obtained. For instance, the line *C* 1 in the plan which corresponds to the elements *C'* 1' and *C'* 1" in the elevation, intersects the cylinder at the points 3 and 4. Drawing vertical lines from these points to the elevation, the point 3' is located on the line *C'* 1' and 3" on the line *C'* 1". In a similar manner points 4' and 4" are located. This procedure must be followed until the entire line of intersection is located, when it may be

The half pattern of the cone is drawn in much the same way. The points of intersection between the elements of the cone and corresponding vertical lines on the cylinder are carried across to the elements *C' A* of the cone, and from there with the trams these distances are swung to the half pattern. The line *M N*, being made equal to one-half the circumference of the cross-section *A-B*, and the spaces *M*-1", etc., laid off equal to the spaces into which the half-section *A*, *B* was divided. Connecting these points with the vertex *C'*, and then by drawing arcs of circles to intersect these lines from points on the corresponding elements in the elevation, the true line of intersection is determined. For instance, the point 3' on the element *C'* 1' is determined by projecting the point 3' across the cone to the element *C' A*, and from there, with *C'* as a center, drawing an arc until it intersects the element *C'* 1' in the half pattern. In a similar manner the point 3" is located by projecting it to the element $C' A'$, and then with the trams drawing an arc from this point until the arc intersects the line C' 1" in the half pattern. Without giving in detail the exact procedure by which each point is found, the reader can see by following through the drawing how the remainder of the pattern is obtained.

2. It is not necessary for a boiler inspector of the United States merchant marine to have sea experience.

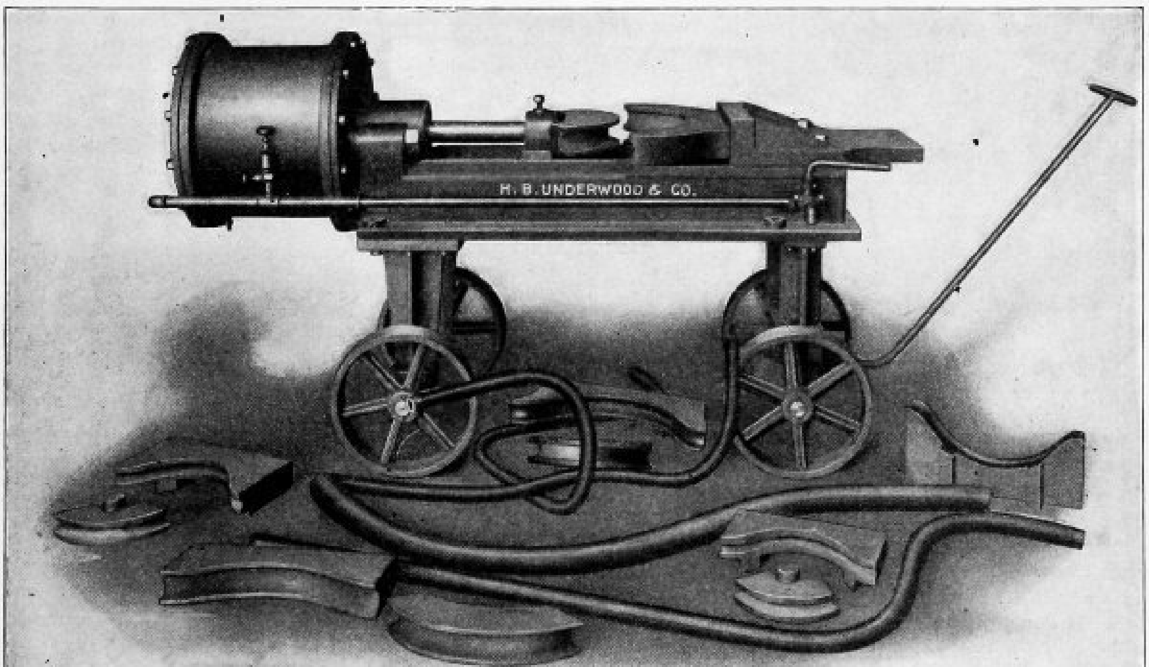
ENGINEERING SPECIALTIES.

A Portable Pipe-Bending Machine.

The range of this machine is so broad that it becomes next to impossible to mention every kind of work for which it might be used. We may safely say that wherever pipe is bent this machine will do it successfully. Its use in a locomotive repair shop, where it did all the bending required for equipping locomotives, including the air-brake piping, demonstrates this and shows the adaptability of the machine.

It can be driven by steam or compressed air, at 80 to 100 pounds pressure, and will bend iron pipe, cold, up to 2 inches in diameter without filling, flattening or spliting the pipe. It is also claimed that right-angle bends can be made in 2-inch pipe in two minutes or less, thus efficiently doing the work almost as rapidly as the pipe can be fed to the dies.

The piston is forced back on the return stroke by a spiral spring, projecting into a round boss of the cylinder head; the front head and piston rod requiring no packing. The end of the piston rod is supported in a crosshead, which slides in the guides. Six dies are furnished, and include sizes from ½ inch to 2 inches. The dies are easily and quickly changed, the female die being centered by a dowel in the angle plate, which is adjustable along the bed-plate, bolted in place, centered and supported against the thrust of the air piston by large dowel pins. The male die is centered and supported on the end of the piston rod, which projects through the crosshead.



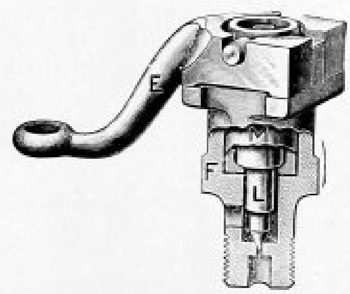
PORTABLE PIPE-BENDING MACHINE, OPERATED BY STEAM OR COMPRESSED AIR.

The truck shown in the illustration is an extra addition, and it is one which has proved so useful as to be almost an essential convenience.

This machine was designed especially by H. B. Underwood & Company, 1025 Hamilton Street, Philadelphia, Pa., for locomotive and railroad repair shop work and for general use wherever it becomes necessary to bend pipe.

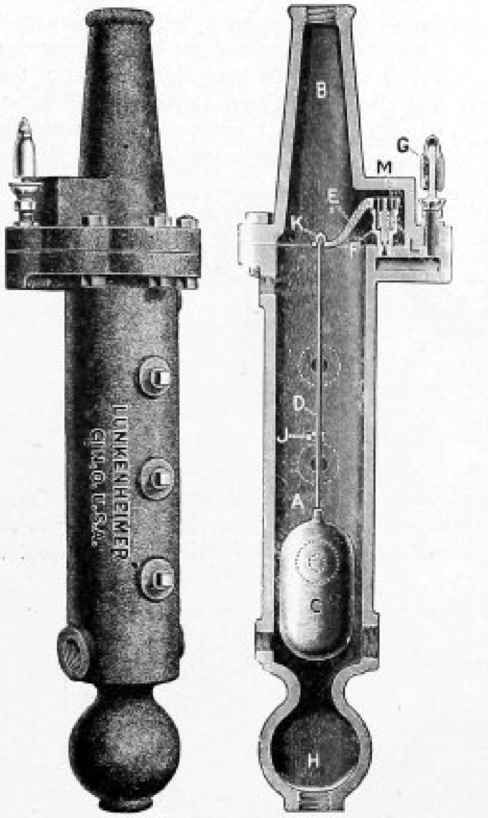
A Reliable Safety Water Column.

The water column shown is so constructed that an alarm is automatically sounded when the water in the boiler approaches the low or high danger limit. The manufacturers claim that they have never had a complaint against the positive action of the column in this respect. It not only safeguards the boiler and its attendants, but from actual tests has demon-



strated the fact that a substantial economy in fuel is effected by its use. This is accomplished by carrying the water in the boiler at the lowest constant level consistent with absolute safety, which increases the steam space in the boiler, produces more steam, hence steadier power, and decreases the consumption of fuel. Steady water carried at the proper level lengthens the life of a boiler, and consequently decreases the number of repairs necessary, making a large saving in repair bills alone.

The columns have gage cock holes tapped on both sides, consequently they can be used as either right or left-hand patterns by transposing the plugs and cocks. If repairs are necessary, the cap *B* only need be removed, when all working parts will be exposed and are easily accessible. It is not necessary to take down the entire column or even to remove the water gage or gage cocks. But one strong seamless copper float is used to operate the signal valve upon the approach of the low or high danger limit. The floats are carefully tested and will not collapse under 350 pounds pressure. The sediment chamber *H* is a very valuable adjunct to the column, inasmuch as it collects the dirt, scale, etc., that would otherwise enter the water-gage fittings and gage cocks. A drain can be provided in the bottom of the chamber to discharge the collected sediment.



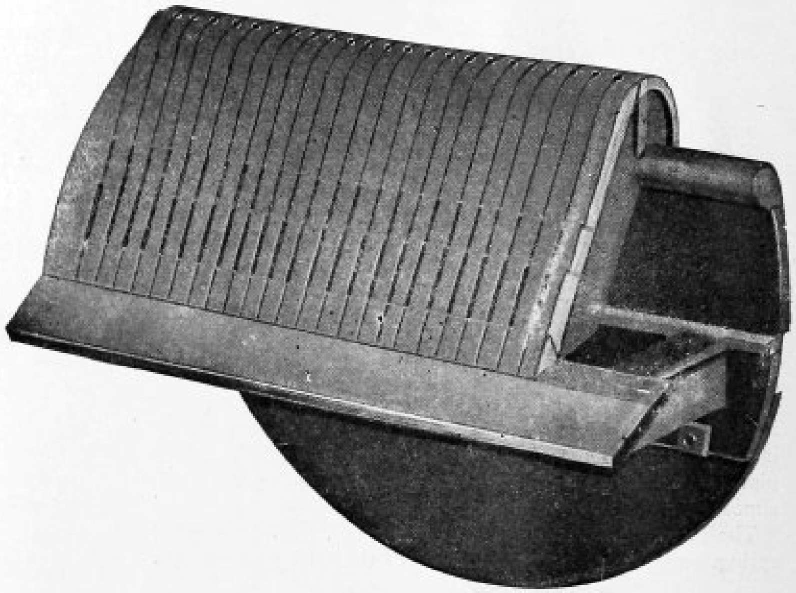
The operation of this improved safety water column is as follows: The float *C* has rigidly attached thereto the rod *D*, which operates through a hole in the valve lever *E*. The stop *J*, which can be placed in any desired position on the rod *D*, strikes the valve lever *E*, should the water in the boiler become too high. Referring to the detail illustration, it will be seen that as the valve lever *E* is raised, it lifts the valve *L* from its seat, allowing the steam from the connection at the top of the cap to pass through the seat opening, and thence to the whistle. The same result is accomplished when the water becomes too low in the boiler. When the float falls, the knob *K*, on the rod *D*, forces the valve *E* down, which also opens the valve, allowing steam to reach the whistle.

The columns are made in various sizes, suitable for all different types of boilers, by the Lunkenheimer Company, of Cincinnati, Ohio. The manufacturers have given this improved device the trade name of "Vigilant."

The Sturrock Furnace Bridge.

A device intended to promote complete combustion of fuel is shown in our illustration. It is designed for both marine and land purposes, and has been fitted to a very large number of steamers. The special advantages claimed for this bridge are: Increased facility in removing and replacing bridges during inspection; facility in cleaning fires, due to such a construction of the bridge that clinker will not adhere to it; great durability, and a better combustion of fuel, resulting in greater economy, and a considerable reduction in the emission of black smoke.

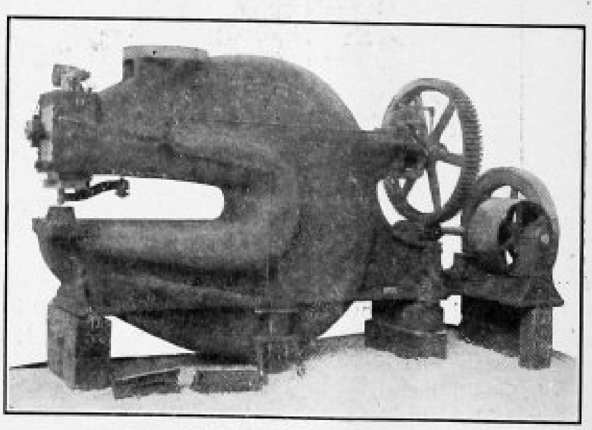
The bridge wall is composed of cast iron bars with considerable air openings between. The dead plate, having openings through it, admits air freely from the ash pit to the back of the bars and through the spaces between to the fire, thus doing away with the usual pile of dead fire against the bridge wall. Air openings are also provided through the bars at the crest of the bridge, by which highly heated air is admitted to mingle with the gases from the furnace as they pass into the combustion chamber, thus effecting their complete combustion and preventing smoke.



This device is placed on the market by the Sturrock Patent Bridge & Engineering Company, Dundee, Scotland.

A Large Punch.

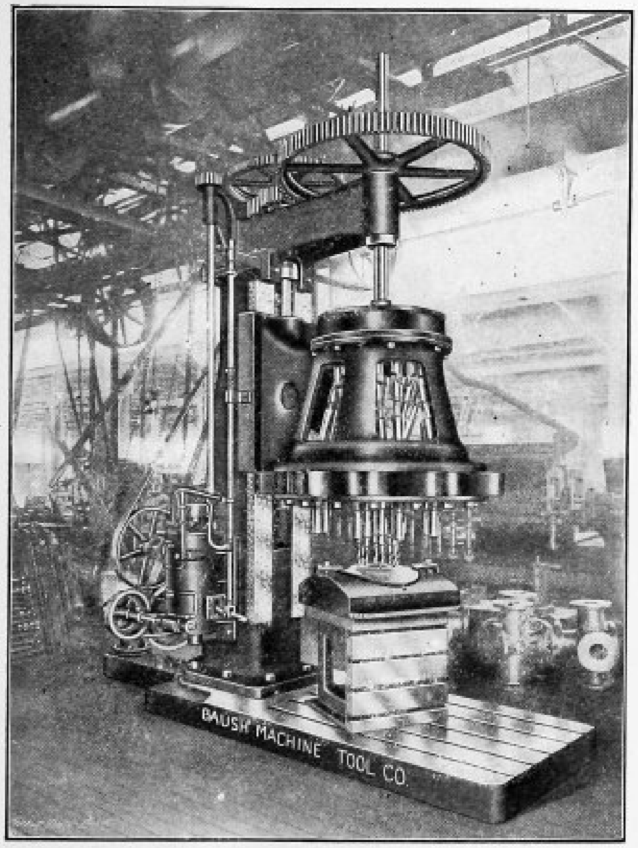
An exceptionally large punch has just been completed by Williams, White & Company, Moline, Ill., for the Standard Oil Company. The machine weighs 6,300 pounds, and is intended for punching the heaviest plates. It has a capacity for punching holes up to 2 inches in 1⅛-inch plate. The distance from the center of the punch back to the throat of the machine is 66 inches. This permits the handling of the largest plates which are usually used in a boiler shop. The



machine is operated by a right-angle drive with a bevel gear and pinion. It is equipped with an adjustable automatic stop clutch. As shown by the photograph the machine has a massive appearance, which is enhanced by the use of a cored section in place of a girder frame.

High-Speed Multiple Drill.

With a maximum drilling circle 30 inches diameter within which the spindles may be adjusted to cover various layouts, the high-speed multiple drilling machine illustrated is regularly equipped with twenty spindles, which have a maximum capacity of 1⅛-inch holes in cast iron. The smallest drill circle, using all spindles, is 17 inches diameter. With eighteen spindles only, the maximum capacity is 1¼-inch holes in cast iron, and the smallest drill circle, using all spindles 15 inches diameter, or with sixteen spindles only, the maximum capacity is 1½-inch holes in cast iron, and the smallest drill circle using all spindles 14 inches diameter. The machine is especially designed for the use of high-speed drills. The speed of the drills is 65 peripheral feet per minute, with feed up to 1 inch per 100 revolutions. It will be seen from the illustration that there are three changes of feed for each cone speed, making nine changes in all, the feed mechanism being driven by the small cones upon the side of the machine. The drilling head is fed up and down the post by a screw of large diameter, which passes through a long phosphor bronze nut, which is affixed to the drilling head. The rapid traverse lever laying across the side of the machine, directly under the feed-clutch lever, gives a rapid traverse movement to the head, to and from the work. The pulley carrying the clutch operated by this lever is belted direct from the countershaft. Direction of head movement is controlled by the position of the vertical lever shown directly under and to the right of the upper feed cone. It has three positions: one directly vertical, which is neutral; one which is further from the machine than neutral, which is for up traverse, and one nearer the machine than neutral, which is for down traverse. The feed-clutch lever laying parallel with the feed-cone shaft throws the feed in and out of engagement, operating the powerful clutch shown upon the end of this shaft. The knockout rod upon the side of the post carries an adjustable stop collar, which should be placed at a distance below the bracket upon the drilling head proportionate to the thickness to be drilled. It also carries a stationary collar directly above the feed-clutch arm which knocks the arm out of engagement when the knockout rod moves downward. Thus, the drilling head may be stopped automatically at any desired position. The spindles are shifted to the desired relative position by releasing the bolts binding the arms to the underside of the drilling head. The minimum center distance of drill spindles is 2¾ inches; the traverse of head on post, 41 inches, and the speed of countershaft, 440 revolutions per minute. This drill is manufactured by the Baush Machine Tool Company, Springfield, Mass.



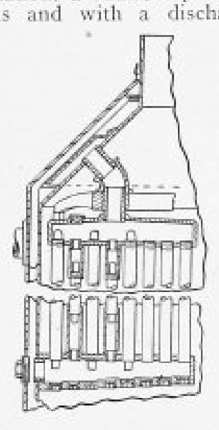
SELECTED BOILER PATENTS.

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.

877,601. STEAM BOILER. William H. Shafer, of Cincinnati, Ohio.

Claim.—In combination, a radial top header provided with transverse manifolds and with a discharge pipe, a radial



bottom header provided with manifolds positioned alternately in different horizontal planes and communicating directly with the water leg of a steam boiler, and tubes connecting corresponding manifolds of the respective headers together. Ten claims.

878,286. BOILER-TUBE CLEANER. Robert O. Hodge, Buffalo, N. Y.

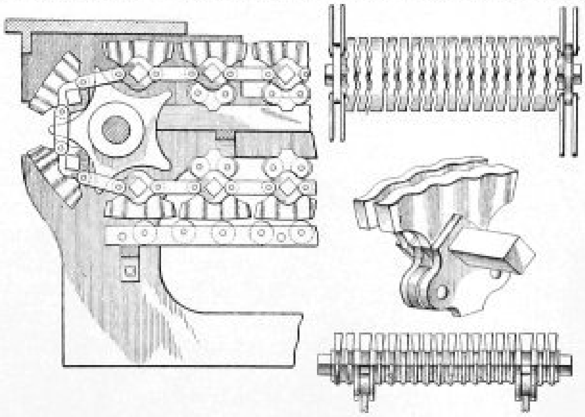
Claim.—A boiler-tube cleaner comprising a rotary body or carrier having a steam inlet, and a steam delivery nozzle mounted on said body and capable of being shifted into different angles relatively to the axis of the body. Twenty claims.

878,330. STEAM GENERATOR. James Blake, of Silvertown, England, assignor of one-half to John William MacDonald, of Silvertown.

Claim.—In a steam generator, a collector pipe having perforations therein and an upturned portion extending above the water level and being open and an ejection pipe inserted in the said collector pipe and extending exteriorly of the shell of the boiler. Five claims.

878,246. FURNACE GRATE. Henry Sieben and Lawrence Danhoff, of Chicago, Ill.

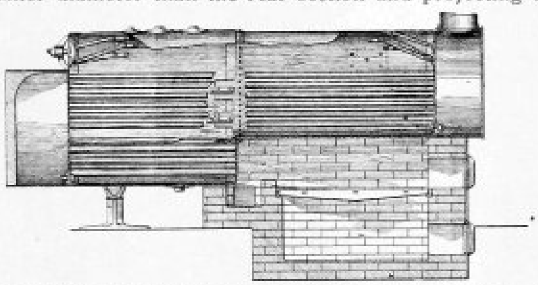
Claim.—In a boiler furnace, a grate comprising grate-bars, independent grate elements strung upon each of said bars, each grate element including a hub portion and a segmental portion, the hub portions being strung upon said bars and the segmental portions forming a support for the bed of fuel, the hub portion of one of the grate elements adjacent each end of each grate bar being provided with spaced depending portions,



a guide roller secured between the depending portions, guide rails arranged to extend longitudinally of the furnace chamber and transverse with respect to the length of the grate bars upon which said guide rollers are arranged to rest, sprocket chains connecting said grate bars, and means for actuating said chains. Four claims.

878,892. STEAM BOILER. William C. Pfeiffer, of Chicago, Ill.

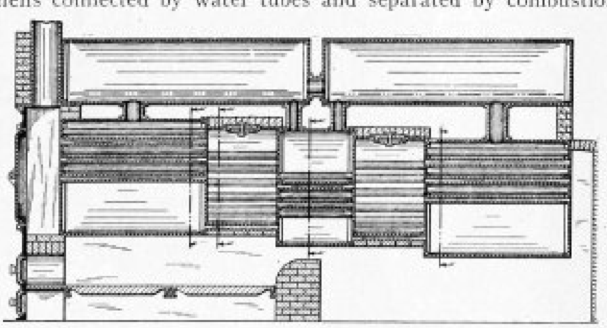
Claim.—In a steam boiler, in combination, a shell comprising two alined cylindrical sections, the forward section being of smaller diameter than the rear section and projecting into



said rear section, said rear section being provided with a rear tube sheet; and stays engaging said rear tube sheet and the inwardly-projecting rear end of said forward section. Two claims.

878,942. STEAM GENERATOR. Harry Del Mar, New York, N. Y., assignor to Boilers & Engineering Company, Jersey City, N. J., a corporation of New Jersey.

Claim.—A boiler comprising a series of water-containing shells connected by water tubes and separated by combustion



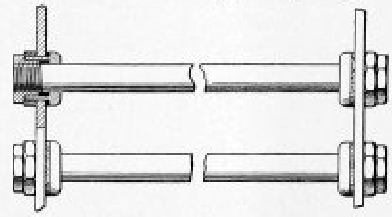
chambers, and fire flues extending through the several water-containing shells, the said fire flues in each section being out of alinement with the fire flues of the next section. Five claims.

878,992. WATER GAGE. John O'Connor, of Clifton, Staten Island, N. Y.

Claim.—In a water gage, the combination of a transparent tube, an intermediate frame member having a longitudinal bore of less length than the tube, snugly receiving said tube and also having interiorly threaded end enlargements, interior shoulders at the ends of said bore and upright, diametrically-opposite sight openings tapered or gradually reduced in width from the inside of the member to the outside thereof, end frame members each having a bore in line with the transparent tube and an enlargement at the inner end of said bore snugly receiving an end portion of the tube, and also having an exteriorly threaded end portion screwed into a threaded end of the intermediate frame member, and gaskets surrounding the end portions of the transparent tube and interposed between the interior shoulders of the intermediate member and the inner ends of the end members. One claim.

879,330. FASTENING MEANS FOR STEAM-BOILER FLUES OR TUBES. Leonidas M. Seaweard, Ontario, Ore.

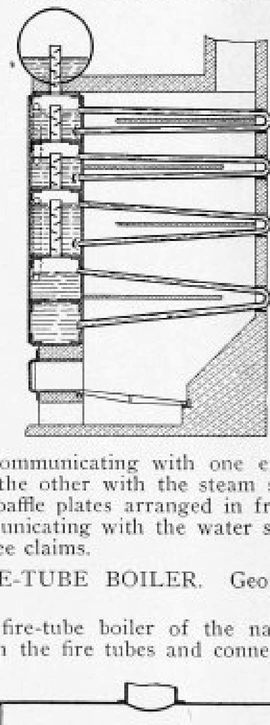
Claim.—A boiler-flue fastening comprising a stuffing-box



secured to the flue sheet, a flue passing through the stuffing-box, and a gland fastened to the flue and having means for holding the flue in place. Five claims.

879,502. STEAM GENERATOR. Jean Van Oosterwyck, Chênée, Belgium.

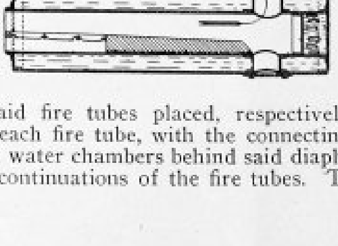
Claim.—A steam generator comprising a plurality of superposed compartments having separated steam and water spaces,



slanting tubes communicating with one end with the water space and with the other with the steam space of said compartments, and baffle plates arranged in front of the ends of said tubes communicating with the water spaces of said compartments. Three claims.

880,672. FIRE-TUBE BOILER. Georg Koch, Lausigk, Germany.

Claim.—In a fire-tube boiler of the nature described the combination with the fire tubes and connecting tubes of diaphragms in said fire tubes placed, respectively, beyond the connection of each fire tube, with the connecting tube leading therefrom, and water chambers behind said diaphrgams formed by perforated continuations of the fire tubes. Three claims.



THE BOILER MAKER

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AUTOGENOUS WELDING OF METALS.

High Temperatures for Industrial Purposes Obtained by Means of Burners.

BY L. L. BERNIER, M. E.

DEFINITIONS.

The so-called oxyacetylene welding of metals consists in the assembling, by means of more or less complete melting of metallic pieces of the same nature, the surfaces of which are brought in contact at a high temperature, without interposition of a different metal from that constituting the pieces.

However, the processes using gas burners affording numerous advantages to the ordinary work of the various industries, only the following processes are actually to be considered:

Oxyhydric burner (oxygen and hydrogen).

Oxyacetylenic burner (oxygen and acetylene).

Oxygas burner (oxygen and illuminating gas).

COMPARISON BETWEEN THE VARIOUS TYPES OF BLOW-PIPES.

As a rule all the oxyhydric burners in use are supplied from ordinary tanks containing the gases under pressure. The actual average prices are: oxygen, 4 cents per cubic foot; hydrogen, about 1 cent per cubic foot.

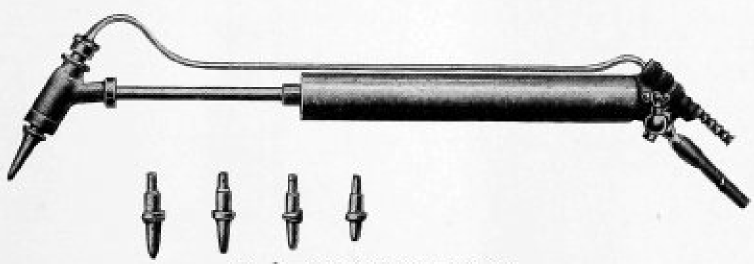


FIG. 1.—OXYACETYLENE BLOWPIPE.

For oxyacetylenic burners commercial oxygen is used; the acetylene comes from one of the following sources: Dissolved acetylene in tanks, where the gas is dissolved in acetone, impregnating a porous material and under an average pressure of 150 pounds; acetylene generating apparatus, producing the gas on the spot under a pressure of about 10 pounds whenever required. The actual average prices are as follows: Oxygen, 4 cents per cubic foot; dissolved acetylene, 2 cents per cubic foot. The cost price of acetylene produced on the spot by generating apparatus is about 1 cent per cubic foot.

Oxygas blow-pipes are supplied with ordinary commercial coal gas from the distributing pipes of special tanks. In the following calculations illuminating gas has been reckoned at the rate of $1.25 per thousand cubic feet:

	Oxyacetylene Mixture.	Oxyhydric Mixture.	Oxygas Mixture.
Temperature obtained by complete combustion of the mixture about................	6,219°	4,156°	3,132°
Number of B. T. U. obtained by complete combustion of 1 cubic foot of combustible gas.	1,570.	290.	616.
Quantity of pure oxygen theoretically necessary for the complete combustion of 1 cubic foot of combustible gas.cu. ft.	2.510	0.620	0.923
Quantity of pure oxygen fed to the blow-pipe per cubic foot of combustible gas (results of experiments).........cu. ft.	1.300	0.250	0.670
Respective quantities of the gases to be fed to the blow-pipe to obtain 1,000 B. T. U. cu. ft.	A .666 O .866	H 3.846 O .96	G 1.81 O 1.21
Cost price of 1,000 B. T. U. (according to above prices):			
Dissolved Ac...........cts.	4.797		
Generator Ac...........cts.	4.13	7.69	5.066

The above figures will be very useful in making comparisons hereafter.

From the point of view of their use the oxyacetylene welding processes may be classified as follows:

Processes admitting of the easy transportation of the welding apparatus to the places where the work is to be done; dissolved acetylene welding; oxyhydric welding.

Processes necessitating the transportation of the piece to be welded to a fixed welding station; oxyacetylene welding, the acetylene being supplied by a generator; illuminating gas welding.

PORTABLE OXYACETYLENE WELDING APPARATUS. DISSOLVED ACETYLENE. OXYHYDRIC.

On the whole, the dissolved acetylene process, while on an equal footing with the oxyhydric process in point of expense of installation and maintenance, is very superior from the following points of view, which are the only ones to be considered in ordinary work:

Price of the gases used.
Cost of workmanship. } Production being equal.
Cost of transportation.

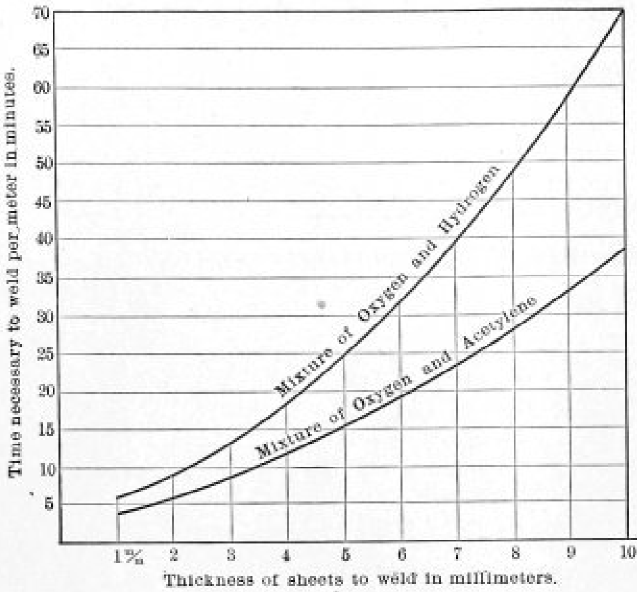


FIG. 2.

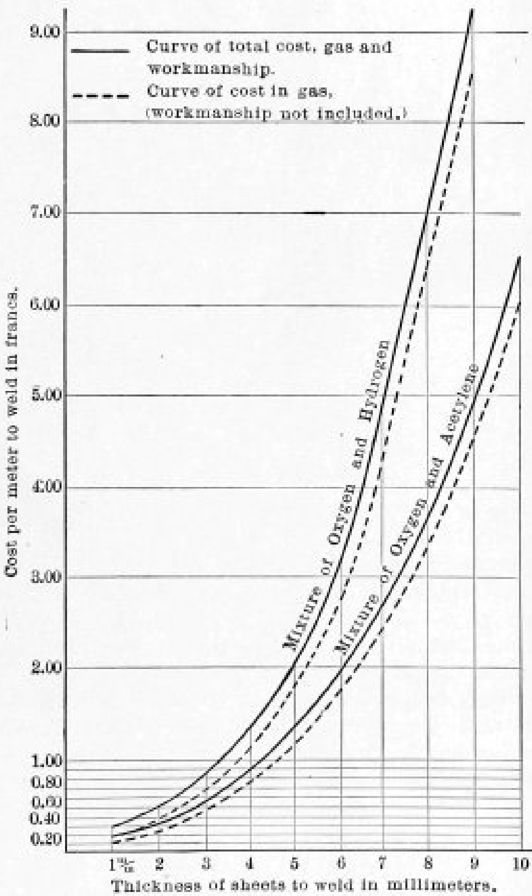


FIG. 3.

Easy regulation of the flame.

Ability to weld large pieces.

On the other hand, the oxyhydric process is to be preferred to the oxyacetylene method in the welding of very thin plates (less than 1/32 inch), which requires less ability on the part of the workman, because its action is not as rapid, the fusing speed of the mixture not as high. This speed, indeed, with an oxyacetylene blow-pipe operated by an inexperienced man, may cause holes in the piece that is being welded, which, however, it is easy to repair.

INSTALLATIONS OF STATIONARY WELDING APPARATUS.

1st. Oxyacetylene supplied by a generator.

2d. Oxygas—Illuminating gas supplied by the ordinary distributing pipes.

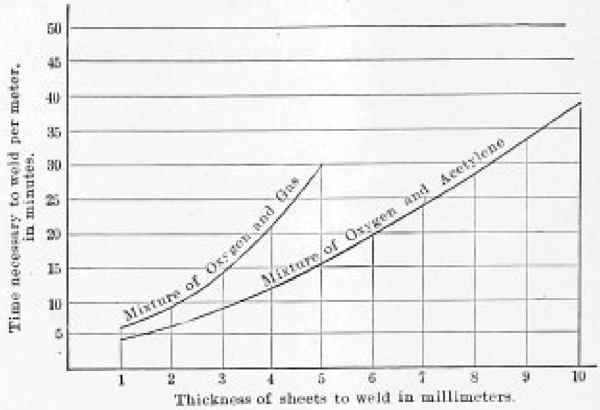


FIG. 4.

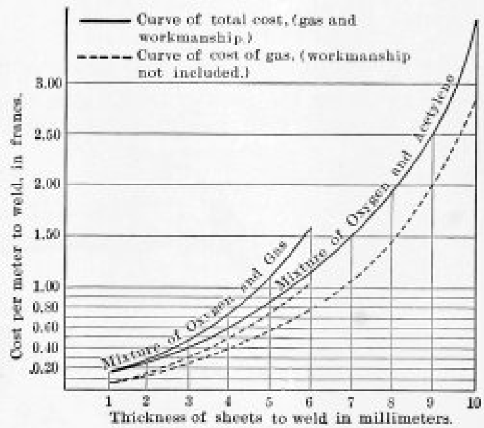


FIG. 5.

On the whole, and if the above curves of cost prices are taken in consideration, the oxyacetylene process is more advantageous than the oxygas, except, however, as regards the cost of installation. Hence the oxygas process should only be preferred to oxyacetylene in cases where the cost of installation has to be taken into account, where the plates to be united are not thicker than 1/6 to 1/5 inch, and where the quality of the weld obtained is of secondary importance only.

CONCLUSIONS.

The above has shown the advantages, in portable apparatus, of dissolved acetylene over hydrogen, and in stationary apparatus, of generator acetylene over coal gas.

When should "pressure" acetylene or "generator" acetylene be used?

It is evident that liquid acetylene imposes itself in all cases where the possession of a portable apparatus is necessary for work outside of the shop, or in the shop on pieces difficult to handle, and also when the work to be done is of short duration.

The smaller initial expense and the easy, perfect control of the consumption are also in favor of dissolved acetylene for experiments, studies and regulation of new manufactures.

On the other hand, the cost price of the work will become the most important factor in steady manufactures, and preference will then be given to generator acetylene, if the plant has enough room for the installation of the generator.

The generator will also be available in shops not provided with a practical system of lighting, or if acetylene is desired as an emergency system of illumination, as, for instance, when the motors are out of commission in shops electrically lighted.

DESCRIPTION OF OXYACETYLENE WELDING PLANTS.

With reference to the various parts of the apparatus the welding installations may be grouped in two classes:

1st. The combustible gas and the gas supporting the combustion enter the blow-pipe under rather high pressures (in general 7 to 15 pounds per square inch), in order to insure to each sufficient velocity at the mouth of the pipe. This refers to the following installations: Oxyhydric, dissolved acetylene and generator acetylene under pressure.

2d. One of the gases, generally the combustible, is obtained from a source where the pressure is only a few ounces, and brought to a lower pressure; this result is attained by the use of regulating valves mounted on the tanks. In the actual work these regulating valves are used in conjunction with gages, constantly indicating the pressure of the gas in the tank, and consequently how much gas is left in it.

The various valves and gages used for oxygen, hydrogen and dissolved acetylene are almost similar, and differ only in the metal of which they are made, but their principle is the same.

Emanating from the regulating valves, the gases are brought through rubber tubes of convenient diameter to the blow-pipe, where the mixture takes place, to be ignited at the mouth.

In the type of installations now discussed both the combustible gas and the supporter of combustion arrive in the blow-pipe under very nearly equal pressures sufficient to insure a speed of the mixture at the mouth of the blow-pipe slightly greater than that of the spreading of the flame through this mixture. Under these conditions, if the working of the apparatus was regular and perfect, there would be no fear of a back draft inside of the blow-pipe. Relying on this theo-

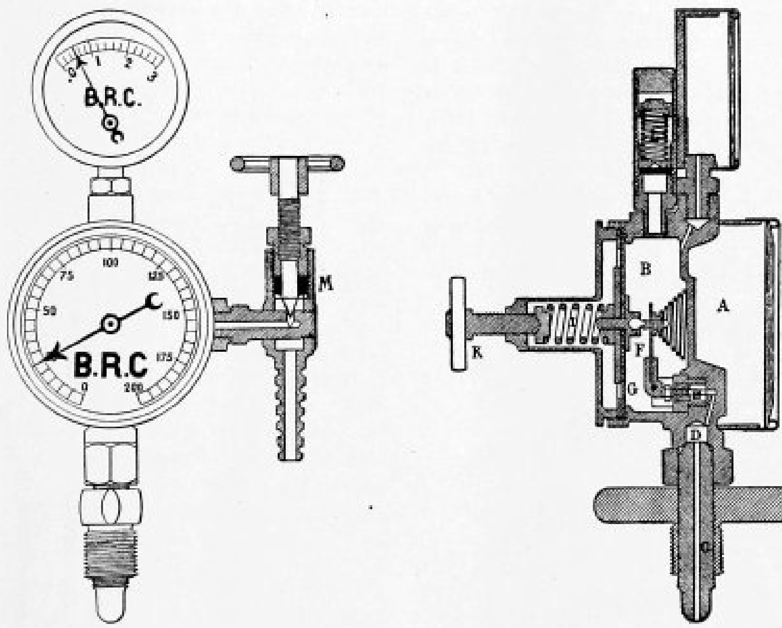


FIG. 6.—REGULATING VALVE.

the other gas must flow under a pressure sufficient to draw out the first and insure a proper velocity to the mixture at the mouth of the blow-pipe. Such are the installations of oxygas and generator acetylene without pressure.

INSTALLATIONS USING BOTH GASES UNDER PRESSURE.

In this class we can make two sub-divisions:

(*a*) Both gases come from tanks where their pressure is higher than that needed in the blow-pipe (oxyhydric and dissolved acetylene apparatus).

(*b*) One of the gases is produced under a pressure nearly equal to that in the blow-pipe (oxyacetylene under pressure from generator).

(*a*) *Oxyhydric and Dissolved Acetylene Apparatus.*

The hydrogen and oxygen used in these processes come from seamless steel tanks, in which they are under a pressure of 150 pounds per square inch. The acetylene is contained in steel tanks, completely filled with a porous matter soaked in acetone, in which the gas is dissolved under a convenient saturation pressure of about 150 pounds per square inch.

These gases, to be used in the blow-pipe, must therefore be

retical impossibility of a back draft, under normal working conditions, a number of manufacturers offered, until very recently, oxyhydric blow-pipes having no safety appliances to avoid a return of the flame inside of the apparatus. But if for any reason (defective working of a regulating valve, insufficient pressure in a tank, smashing or folding of a rubber hose, contact of the end of the blow-pipe with the pipe to be welded, etc.) the speed at the mouth became for an instant inferior to that practically necessary, the blow-pipe became red hot, burning the workman's hand, and the flame ran back as far as the rubber tubes, which were burned; the valves had to be instantly closed and everything put in shape again.

In the oxacetylene blow-pipe of the Dissolved Acetylene Company the safety appliance is located inside of the apparatus; the back draft is avoided by a particular construction, by which the mixture of acetylene and oxygen convenient for the welding flame takes place in a very small space near the mouth of the blow-pipe. From this mouth to the source of the gases the quantity of acetylene in the mixture decreases. The explosive wave, coming in contact with parts of gas of decreasing explosive power, slackens rapidly. The result is a very reduced localization of back drafts. This appliance is also completed by the interposition, in the supply pipe of acetylene, of a porous screen, which effectively stops the flame, a result that could not be obtained by a cushion of wire gauze, contrary to general belief.

(*b*) *Oxacetylene Installations with Generator Producing Acetylene Under a Pressure of About 7½ Pounds.*

The blow-pipes employed in this case may be simply mixers of gas, as above, with the condition, however, that the pres-

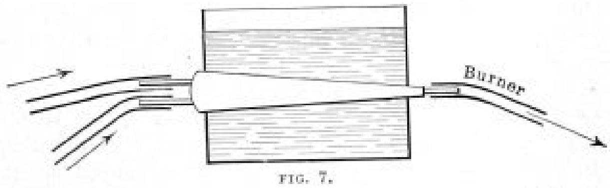


FIG. 7.

sure of the acetylene supplied by the generator be sufficient to insure to the mixture a speed at the mouth superior to that of the spreading of the flame (a condition which is generally realized in these instruments). But the installation is, however, different from the others. If we suppose that for some reason one of the gases, through an excess of pressure, has a tendency to enter the flask containing the other gas, it is easy to understand, by referring to the description of the above regulating valves and manometers, that the construction of this apparatus renders impossible the connection of one of the tanks with the other.

In the case of installations with generator producing acetylene under a pressure of 7½ pounds the acetylene regulating

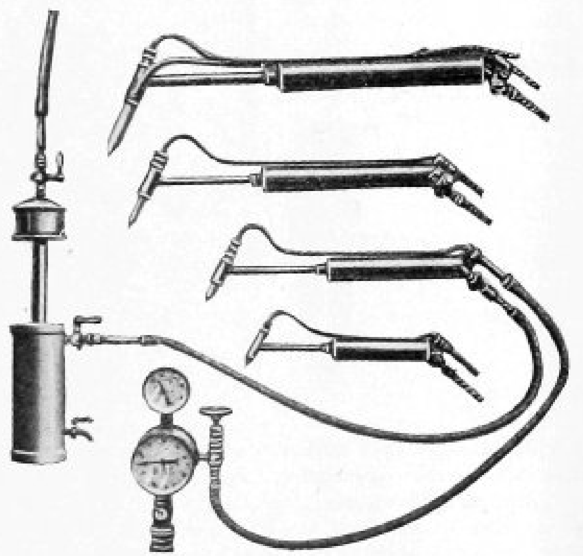


FIG. 8.—APPARATUS ASSEMBLED.

valve and manometer do not exist, and nothing would stop the oxygen coming out of its tanks to get into the acetylene generator. In order to avoid this possibility of accident it is necessary to interpose in the acetylene pipe, between the blow-pipe and the generator, a safety hydraulic interrupter. (See *Technologic Bulletin*, December, 1903, page 1,348.)

INSTALLATIONS USING ONE OF THE GASES TO DRAW OUT THE OTHER.

The acetylene produced by ordinary generators for lighting purposes and the coal gas distributed in the cities are under a pressure of only a few ounces of water.

The oxygen always comes from tanks where its pressure is 150 pounds per cubic foot.

A regulating valve and manometer, placed on the oxygen tank, reduce the pressure of this gas to 15 pounds, under which it is fed to the blow-pipe. The latter is provided with an injector, the diameter of which changes according to the quantities of oxygen required. The oxygen, acting as motor, brings the combustible gas in, and in this way it is possible to regulate the speed of the flame. This is the principle of all the blow-pipes of this class, the difference consisting of more or less perfect details of manufacture.

The first blow-pipe using acetylene without pressure was invented by Mr. Ed. Fouché (August, 1877).

On account of the considerable difference between the pressures of the oxygen and the combustible gas, and in order to avoid a flowing back of the oxygen in the pipes of the combustible through any accident, it is necessary to interpose on these pipes, and as near the welding point as possible, an hydraulic safety valve. This appliance, Fig. 9, is composed of a central tube *A* for the combustible gas, terminated at its lower extremity by a bell-shaped casting, on the circumference of which are numerous holes through which the gas escapes, reaching the blow-pipe through the tube *S*. The valve chamber is filled with water to the level of a gage cock *R*, and is also provided with a safety tube *B*, the lower end of which is slightly below the normal water level. The top is connected

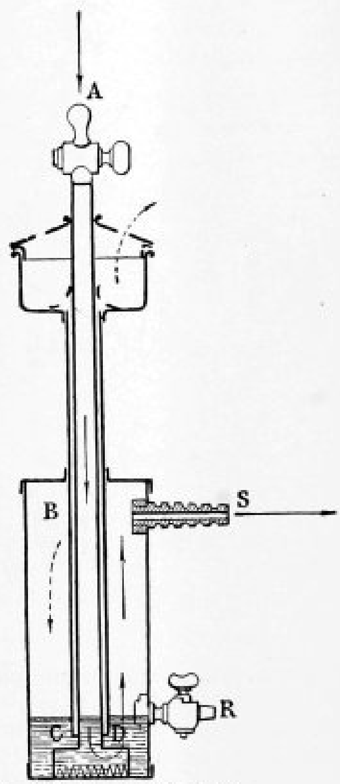


FIG. 9.—HYDRAULIC SAFETY VALVE.

with a basin communicating with the air outside by holes in the cover.

In case of an accidental flowing back of the oxygen in the apparatus, the water rises in the tubes *A* and *B*, and the section *CD* of the safety tube *B* is uncovered; the gas escaping outside and no flowing back can occur in the central tube, which remains immersed in water.

The water carried away is collected in the upper basin, and falls back to the bottom.

BLOW-PIPES.

As previously said, all the blow-pipes used in these installations are identical as to principle, the only difference between them being the details of manufacture, rendering their working more or less perfect and their manipulation more or less safe.

The safety appliance placed on the acetylene pipe, avoiding all back drafts of the flame, is one of the most important parts of the welding tools.

The French company for the dissolved acetylene process uses a porous material. In the Fouché system the acetylene goes through a series of very long and very thin tubes. In other cases an accumulation of metallic gauzes is resorted to, which is more dangerous than efficacious, and others solve the problem by the complete absence of the safety appliance.

Although it is not our intention to describe the various systems of blow-pipes, we shall draw attention to two systems, still unknown because they are very new.

1st. Warming up of the gaseous mixture before its inflammation.

The insufficient temperature of combustion of coal gas led to appliances for heating it. The company using the compressed gases, to attain this end, warms up the oxygas mixture by means of a flame, bringing to red heat a coil through which the mixture passes. It is evident that this disposition insures a higher temperature of combustion, but its slow action speaks against it. At the moment of lighting, the coil is cold, and the heater has no action on the mixture; its action is only progressive, following the warming up of the coil, so that this disposition is only interesting in cases where the blow-pipe must work without stopping for a long time. This disposition is of no value in the works necessitating the lighting of the blow-pipe for only short periods.

2d. Blow-pipes with interchangeable heads for various sizes of flame. To facilitate the work, and to reduce the consumption of gas to a minimum, it is necessary to use blow-pipes giving a flow of gas in proportion to the work to be done. In the case of a blow-pipe where one gas brings in the other, the sections of the injector and of the pipes for the gas carried in, the shape, the sections, and the length of the mixing and egress chambers must be well determined for a given flow. The result is the necessity of making a blow-pipe for each of the necessary flows. Undoubtedly, certain manufacturers have pretended that they obtained flames of different volumes, in which the mixture of the gases was perfect, with the same blow-pipe, the same injector, the same mixing parts, by simply changing the mouth of the blow-pipe. This assertion has no foundation, and experience has shown the imperfect working of these blow-pipes.

By a special adjustment of its blow-pipes the B. R. C. Company has realized the grouping in a head easily removable of all the parts, the form and section of which is variable with the required flow. The result is that with only one body of blow-pipe and a series of these removable heads, it is possible to obtain a great variety of flows, rendering possible the execution of very different classes of work.

This disposition is of value for the shops where oxyacetylene welding is seldom made, and on pieces of very different thicknesses.

3d. *General comparison between the blow-pipes of the first class (gas under pressure) and those of the second class (one gas driving in the other).*

Certain shops, noticing marked differences between the work obtained with the same gases (acetylene and oxygen), but in one case with blow-pipes of the first class (gas under pressure), and in the other with blow-pipes in which one gas forces in the other, came to the conclusion that the former were superior to the latter.

This superiority, although real, is not, however, as great as one might be tempted to believe, because if certain blow-pipes where one gas brings the other in are not carefully watched, the few types generally used in the shops admit of a complete mixture of the gases and of a perfect mixture, the flame of which is in all respects similar to that of the other blow-pipes.

The inferiority, if it may be so called, of the blow-pipes of the second class, arises from the following fact:

When the workman starts to work and regulates the flame of his blow-pipe, its mouth is at the same temperature as the surrounding air. In the course of the work the diameter of this mouth increases in a certain proportion on account of the heat; on the other hand, particles of melted metal or oxide are always projected and may obstruct this mouth more or less. The result is that the volume of the issuing mixture is variable during the work.

In the blow-pipes where the gases come in under the same pressure this modification of the diameter of the mouth has no other consequence than a variation of the flow; the proportion of the gases in the mixture does not change, and it follows that the nature of the flame is not modified.

On the contrary, in the blow-pipes where one gas carries in the other, the quantity of oxygen passing under high pressure through the injector remains nearly constant, notwithstanding the variation of the orifice area, whereas the quantity of acetylene carried is subject to fluctuations. The consequence is a certain irregularity of the flame, generally hardly noticeable, requiring only a closer watch on the part of the workman.

Helpful Hints for Boiler Makers.

The accompanying drawings are published through the courtesy of Mr. G. W. Bennett, master boiler maker of the West Albany shops of the New York Central Railroad, with the hope that they will be of some benefit to boiler makers in general throughout the country. They serve to illustrate the close attention that is given to details at these shops, a fact which has been of material assistance in bringing this plant to the high state of efficiency for which it is noted.

The first illustration presents a standard diagram for ascertaining the various lengths of stock required in rivets for different thicknesses of metal. The diagram is reproduced one-half its actual size, and so in using the diagram the result should be multiplied by two in order to get the actual values. The way in which this diagram is used is as follows:

To find the proper length of a rivet to be used in joining

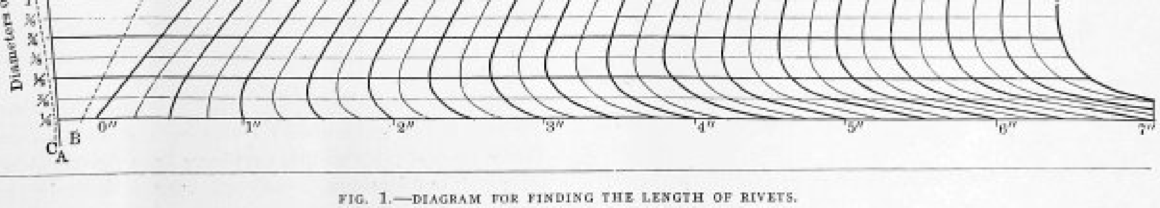


FIG. 1.—DIAGRAM FOR FINDING THE LENGTH OF RIVETS.

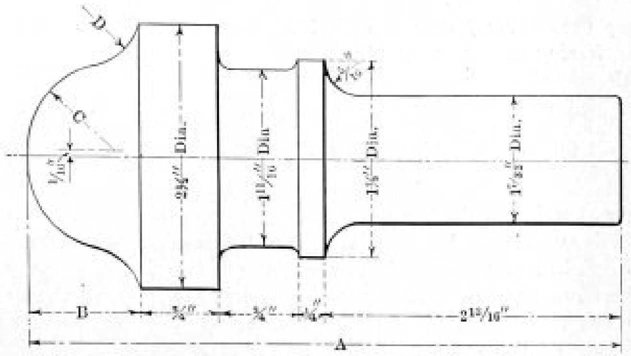


FIG. 2.—"TURNING-OVER" TOOL.

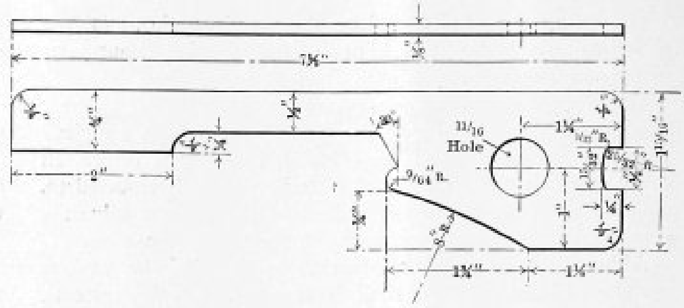


FIG. 4.—GAGE FOR BEADING TOOL.

plates of a given thickness measure with a foot rule from a point on line *a-a*, opposite the desired diameter of rivet, along the horizontal line to the curve springing from the required grip. The grip is, of course, the total thickness of the several sheets of metal which are to be riveted. This length must be multiplied by two, on account of the reduction in the size of the drawing for reproduction on this page. For the length of countersunk rivets, measure from the broken line *b-b* instead of from the line *a-a;* for cone-head rivets measure from the dotted line *c-c* instead of from the line *a-a.* The rivet holes should be 1/16 inch larger than the diameter of the rivet.

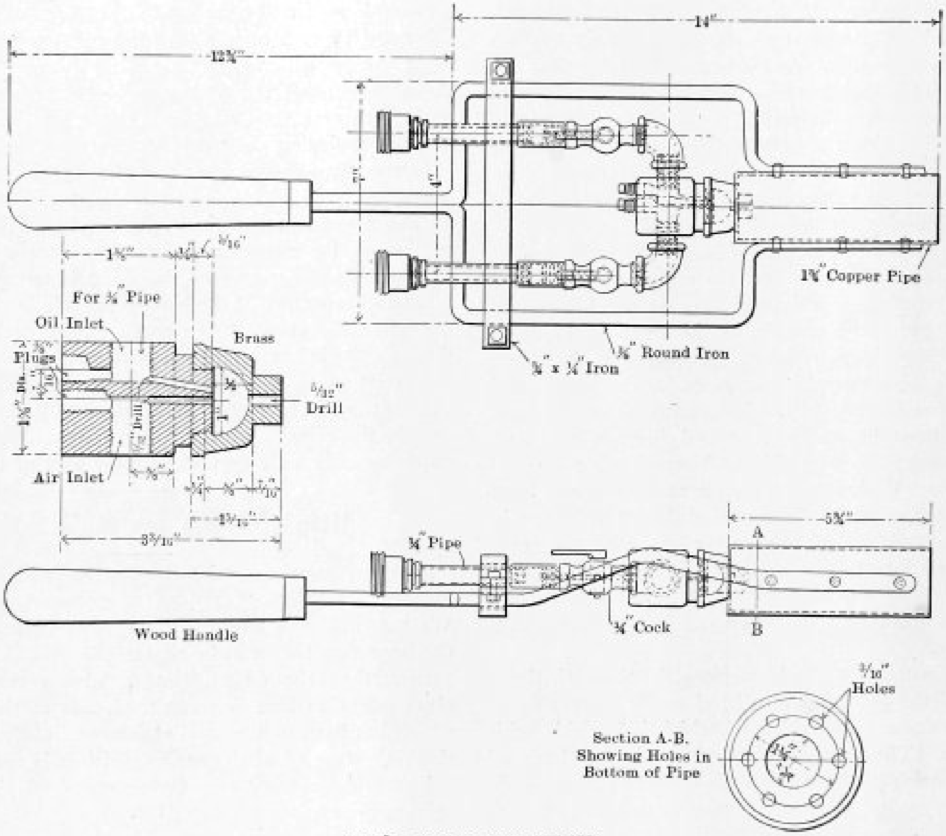


FIG. 5.—PORTABLE OIL BURNER.

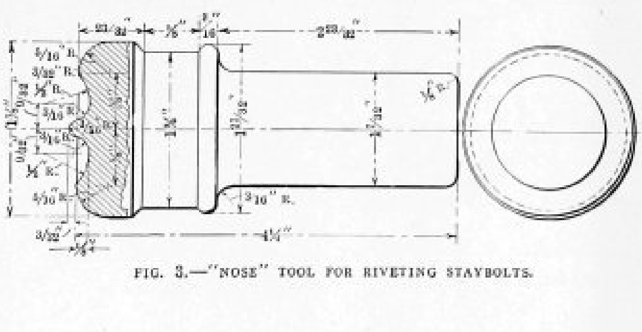


FIG. 3.—"NOSE" TOOL FOR RIVETING STAYBOLTS.

The second illustration shows a detail drawing with dimensions for a "turning-over" tool, to be used in conjunction with a long-stroke pneumatic hammer as a preliminary operation to the beading of the tube. This tool differs but slightly from the "turning-over" tool in general use; the main difference being in the large radius at the point marked *D*. After extensive experiments the large radius has been found to give better and quicker results, and it also prevents the possibility of a sharp "turn-over" with possible cracking of the tube. It leaves a nearly-finished job, which will require only a small amount of work with a beading tool. The gage for the beading tool is shown in detail in drawing No. 4.

The dimensions for Fig. 2 are shown in the following table:

D	C	B	A	Used on
1/2	13/16	1 1/16	5 5/8	2-inch boiler tubes swedged to 1 7/8
7/16	3/4	1	5 11/16	2-inch boiler tubes swedged to 1 3/4

Fig. 3 is a "nose" tool, also used in connection with a long-stroke pneumatic hammer for riveting the heads of stay-bolts. While several tools of this sort have been described in various technical publications, nearly all have lacked the necessary details, dimensions, etc., which will enable anyone to reproduce the tool. All dimensions and details are clearly shown in this drawing, and these are standard on the New York Central lines.

In Fig. 5 the details and general dimensions are given for a handy oil burner, which may be readily constructed from odds and ends picked up about the shop. This burner is unique, in that it requires no casting whatever, or any connections of an intricate nature. This is a handy device for work wherever a portable burner is required, and it has been used with great success in the West Albany shops. While the success which anyone will have in duplicating this burner will depend largely upon the ingenuity of the man himself, and upon the materials at his disposal, yet the general idea given in this drawing can easily be followed in its essential details without a very great tax upon the resources of the builder.

Such devices as those illustrated in this article show only in part the amount of thought and attention which have been gives to working out small details in these shops. A large new shop is now nearly completed at this plant, which, when it is fully equipped, is expected to be one of the largest and most modern boiler shops in the country. None of these small details are overlooked in the splendid equipment of the new shops.

CHARLES DOUGHERTY.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.

Proceedings of Second Annual Convention at Detroit, Mich.

The second annual convention of the International Master Boiler Makers' Association was held at the Hotel Pontchartrain, Detroit, Mich., May 26, 27 and 28, 1908. The opening session of the convention was called to order at 10:30 o'clock on the morning of May 26, by President George Wagstaff. After an invocation by Reverend Lee S. McCollister, the president introduced Mr. George W. Moody, president of the Detroit Board of Commerce, who, on behalf of the Mayor and citizens of Detroit, welcomed the members of the association and their guests to the city.

MEMBERS AND GUESTS OF THE INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION AT DETROIT.

In the course of his address Mr. Moody pointed out the fact that what makes our country great is its opportunity, showing that none are in a better position to appreciate this than the men who, like the master boiler makers, have come up from the ranks of the toilers and have reached their present places of prominence, responsibility and prosperity by their own efforts.

After a brief response to Mr. Moody by Mr. J. H. Smythe, President Wagstaff introduced Mr. E. D. Bronner, superintendent of motive power of the Michigan Central Railroad.

ABSTRACT OF MR. BRONNER'S ADDRESS.

As a superintendent of motive power, I desire to express my appreciation and approval of the good work you are doing in the line of business which brought you here in convention. I am interested in the name of your association, the International Master Boiler Makers' Association, and when I look around me I see the faces of men that I am familiar with, men with whose ability I am acquainted, and I know that there are many masters of this business here.

Nowadays a master boiler maker means more than the boss of the job. A master boiler maker now ranks nearer to the professional, and in some phases of the work it is getting to be a fine art. Now, how will a mere boiler maker become a master of this important business? By constant study, by analysis, by experiment, by experience, by comparison, by high development of the powers of observation. This can be carried out by any man in his own bailiwick, but the sum total of the experience and ability of this profession in this convention is surely greater than that of any individual. And how can a man come up and rub up against the cream of his profession here for four or five days and go away without a great stimulus toward greater effort and greater perfection in his work for the rest of the year?

In these days of monster locomotives carrying heavy steam pressures, consuming large amounts of coal per hour, transmitting large heat volumes through the sheets and tubes of boilers, there are many new problems to meet and master, which differ radically from those of some years back. These problems must be met by you. The mechanical engineer with his technical knowledge can design a boiler adequate in all respects as to safety against pressure, heating surfaces, water spaces, grate areas, etc., he can put under it and on it the proper running gear, machinery and appliances. We then have the locomotive, which is the vital part in the operation of any railroad. This design may be all right, this boiler may be strong and big, but nevertheless it is a delicate thing. It must be properly put together in the first place, it must be watched, tested, manipulated, washed, attended to, or the whole machine is inefficient and ineffective. This is where the fine art of your profession comes in. It is not easy to keep an equipment of locomotives, coming and going in their turn, doing their work efficiently and effectively. To obtain this efficiency and reliability the master boiler maker must know his business, and he must be a man who does things. It is not sufficient to theorize or even to know how a thing should be done; it is his business to know that it is done.

Vice-President Wilson responded briefly to Mr. Moody, after which the reports of the president, secretary and treasurer were read. A number of names were presented for membership, and after some discussion as to eligibility, were accepted.

P. J. CONRATH, PRESIDENT.

ABSTRACT OF PRESIDENT WAGSTAFF'S ADDRESS.

The importance of correct principles and good workmanship in boiler construction cannot well be overestimated. The steam boiler is to-day the most potent factor in our complex civilization.

Strict adherence to established rules and formulas should be the guiding principle of boiler making, and under no consideration should a boiler maker deviate from those well-known laws of accuracy and safety—not even to increase his own earnings or satisfy the cupidity of his employer. A slip of a surgeon's knife may mean the destruction of one human being, and the fact that the use of the knife was necessary indicates that the patient was in a bad way, while the calking up of an incipient crack or the starting of one by carelessness, or cracks which develop in bending plates and are hidden by welt strips and poor threads on threaded holes in which are inserted stay-bolts or patch bolts and called "good enough," finds no place in the boiler maker's art.

In no calling known to the speaker are there such opportunities for doing poor work without detection as in boiler making. Therefore guard your reputation above all things.

ABSTRACT OF SECRETARY'S ANNUAL REPORT.

The numerical growth of the association in the way of new members and a return of those who wandered from its fireside has not met expectations. At an early date following the Cleveland convention, a campaign circular was sent out urging upon members the need, value and importance of individual effort with a view of gaining accessions to your ranks by bringing in new men and persuading delinquents to renew their affiliations. Only twenty-three new applications for membership had been received when this report was completed, the majority being from your president. It is gratifying to say, on the other hand, that but two resignations have been received, which suggests that the association and its work is fully appreciated. Only one death occurred during the year—Mr. R. H. Jackson, who died April 25, 1908.

The total number of members paying dues to April 1, 1908, either to my predecessor or myself was 282, and 55 are still in arrears for 1908. If these had paid, and adding the 23 new applications, the number in good standing at this time and enrolled would be 340.

The secretary would very earnestly urge upon members the absolute necessity of always giving immediate notice of change of title, business connection and postoffice address. In no other way can the delivery of association literature, etc., be assured.

Under the direction of the president and executive committee the programme for this convention was arranged with a view of insuring system in the transaction of its business, the presentation of papers and the discussions to take place from to-day. An effort was made to place in your hands advance printed copies of all papers, such as you have received, which would have reached you sooner had committees been more prompt in sending their reports on the appointed date. It is a matter of gratification, however, that the majority eventually forwarded their papers. In the light of this year's experience and the advantage afforded, it should be possible to do this work more satisfactorily in advance of the next convention.

Experiences in the office of the secretary in handling your affairs have suggested the need of an immediate revision of the present constitution and by-laws to the end that certain features may be improved upon for the general good of the association and to facilitate the transaction of business and other matters which cannot be foreseen, and which from time to time require prompt attention.

The president's report was referred to the committee on distribution with respect to the recommendation, and the reports of the secretary and treasurer were referred to the auditing committee.

The following committees were announced by the secretary: Committee on President's Address—Messrs. Brown, Fletcher, Hempel. Auditing Committee—Messrs. Raps, Murray, Shoemaker, Fletcher, Besant. Committee on Resolutions—Messrs. Smythe, McKeown, Lester. Committee on Next Place of Meeting—Messrs. Conrath, Laughridge, O'Connor, Stowings.

WEDNESDAY MORNING SESSION.

President Wagstaff called the meeting to order at 8:45 o'clock. The first subject taken up was the report of the committee on boiler flues.

Boiler Flues.

The committee which had the subject of the best method of applying flues to locomotives under consideration, reported that the operation of applying flues is very nearly universal in almost all railroad shops, the main difference being in the use of the roller and prosser expanders. The work is usually done as follows:

First, prepare the flue hole by removing the scale or burr from flue hole; also true up the hole by using a reamer made for that purpose. Then remove the sharp edge from the flue hole inside and outside of back flue sheet. Put in copper ferrules, allowing them to project 1/32 inch inside of face of flue sheet. Expand ferrule into flue hole, using sectional expander.

The flues are prepared and swedged to fit into the copper ferrules nicely by applying three or four blows with a driving bar, made for that purpose. They are opened, or mandreled out, as you prefer to call it, with a sectional expander with the hub of expander ground off and used as mandrel. Flues are allowed to extend 3/16 inch for bead.

The flues are rolled with the use of air motors, and flaired over by the use of what we call a bob, made expressly for that purpose, used in connection with a long stroke hammer. They are then prossered by the use of a jam riveter; the prosser turned three times in operation, and are then calked by standard beading tool, made to gage, used with pneumatic hammer.

This report recommended that whenever flues leaked, the leaks should be stopped by the use of the sectional expander, and that when the tubes are poor or thin, and, in the judgment of the workman, there would be a possibility of bursting the tubes, the sectional expander should be used with the shoulder ground off. In case the tubes are so poor that leaks cannot be stopped with the sectional expander they are removed. The assertion was made that flues cannot be put in locomotive boilers better than they are at the present time, and the fact was pointed out that with an iron shim wrapped around the flue for a ferrule, and with the flue only rolled, not beaded, the flues in the front end of the boiler give hardly any trouble at all. The cause for the leaking of flues at the fire-box end is due to a number of things, principally to bad water and great variation in temperature. It was recommended that when a fire is cared for it should be placed forward and the front grates kept covered to prevent cold air coming in contact with the flues and back flue sheet.

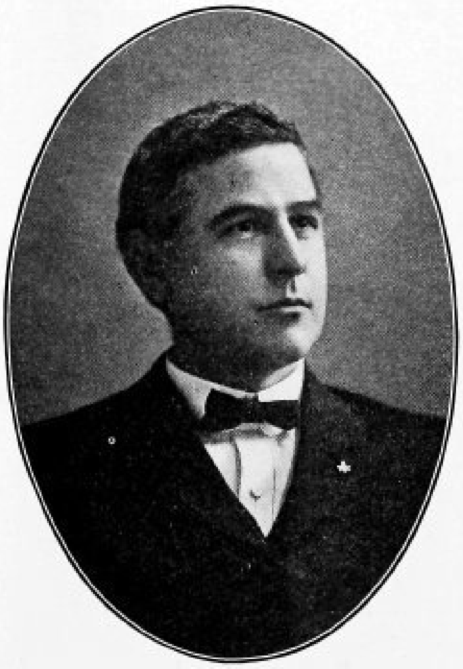
The report of the committee was accepted and the subject was opened for discussion.

Mr. A. N. Lucas—We use a prosser expander exclusively in the fire-box. We do not use the roller at all in setting new flues or repairing old flues. I think a great deal of damage in the roundhouse to the flue and to the bead is due to heavy expanding. After you have set the flue properly at the first setting with a prosser expander, it has the full contour of the expander, and when the flues leak it certainly does not require the heavy pounding used at first. I think if the flues in the roundhouse are cared for by using a lighter maul, the same hammer you use for pounding up large stay-bolts, turning your expander two or three times and then beading lightly you will get very much better results than if you go after them and "hit 'em hard."

Again, when you expand your flue you use a ⅝-inch expander, that is, from shoulder to ball; the bead is not down against your sheet, and it expands the flue inside of the sheet properly. Now if you use that same expander on repair work it will go inside of the flue 1/16 or 3/32 inch farther than it did when you first expanded the flue. That will tend to ball the flue up farther inside, but it doesn't fit in the original groove, and consequently you do not get the results you are looking for. I believe we should use a shorter expander in the roundhouse after the flues are beaded.

The President—There is one thing in regard to this subject I would like to refer to and see if the members have an opinion in regard to it, and that is the exclusive use of a sectional expander. It is a very important question in the East, and the opinions of the members of this association will be valued by a good many people who handle flues in the Eastern districts.

Mr. Roesch—We are just as interested in preventing the flues from leaking as in doctoring them after they begin to leak. Now we have been frequently criticised for poor workmanship, when probably the entire trouble was poor handling of the boiler after it is in service. Have you ever noticed the intimate relationship that exists between washing a boiler and flue leakage? We speak of bad water causing flues to leak. That is true, because the worse the water is, the more frequently we have got to wash the boilers, consequently the shorter the life of the flues. I have been pretty much interested in the flue problem practically all my life, because at one time I was connected with a railroad that, on one certain division, had no flue troubles whatever. We put the flues in and forgot about them. On another division of the same



A. E. BROWN, FIRST VICE-PRESIDENT.

railroad, if a set of flues passed three months we did pretty well. I noticed on the division where we had no flue troubles that we never washed a boiler. Now that is a strange proposition, but it was up in the mountains, with absolutely pure snow water, consequently there was no mud in the boiler. On the other division we had an alkali water which made it necessary to wash the boilers every trip.

Mr. M. E. Wells, who is an authority on locomotive boilers, made the statement at one time that the leaking of flues was all due to the difference in the temperature of the boiler; that is, the difference in the temperature of the water itself. When I became connected with the Southern Railway I thought I would see what that difference amounted to. I made some trams so that I could tram the length of the flue immediately after the fire was knocked, and at the same time tram the length of the boiler between the flue sheets. I found that shortly after the fire was knocked, the flue contracted more than the boiler; that is, it pulled in the boiler, probably 1/64 or 1/128 inch, because the cold air passing straight through the flue contracted it while the boiler was still full of hot water, and was protected by a jacket and lagging on the outside, which kept the boiler from cooling as quickly. Finally, however, the boiler commenced to contract and contracted more than the flue; in other words, it started to push the flue out of the flue sheet. I found the difference in the contraction to be about 1/64 inch in the first contraction. That is, the flue shortened about 1/64 more than the boiler, then the boiler shortened more than the flue, then finally the flue shortened, after the water became cold, until they both became the same length again. Now that shows that there is this pushing and pulling action going on in the boiler all the time.

On account of the back flue sheet being exposed to a greater degree of heat, we have all our troubles in the rear end. I thought I would see what effect the stopping of the washing of boilers would have on this. We have good water, only mud in it, no scale, no encrusting material or anything of that kind. I put a lot of draw-off cocks on the engines, and engines that we used to wash out every week ran thirty days, some of them sixty days. We never knock the fires any more, and we don't have to send the boiler makers out any more. Therefore it seems that there is an intimate relationship between the number of times the boiler is washed

J. J. FLETCHER, SECOND VICE-PRESIDENT.

and the number of times the flues leak, or the number of times that you have to renew flues, and of course the worse the water is the shorter the life of the flues.

Mr. Flavin—I find that in many places they are overcoming a great deal of flue trouble by using the waste water from the boiler for washing out; in fact it has become a standard practice throughout the entire West. There is no question about the expansion of the flue sheet; it must be accommodated. It was brought to my mind very forcibly in a condition wherein we received some engines furnished with 5/8 flue sheets. In every case in which I renewed these flue sheets I used a 1/2-inch flue sheet, and in smaller engines 7/16, merely to accommodate that necessary expansion, and I found that with flues 19 or 20 feet long, instead of the sag having a tendency to loosen the flues, I got better service out of the long flues than the short ones.

I believe that the action of the prosser expander can be governed entirely by having a shoulder resting on the flue sheet proper, as well as on the bead of the flues. In that way the prosser expander will always enter the flue the same distance, and we will always make the same joint unless the sheet is worn to such an extent as to make a vast difference. As to the use of the prosser expander alone, while this is of course endorsed in boiler practice throughout the country where there is ordinarily bad water, or fairly good water, it probably is successful in the case of the first one or two or three sets of flues, but where conditions exist where a flue sheet will receive seven or eight sets of flues before it is removed, the holes gradually become oblong, and there is no prosser expander on the market to-day that does not expand centrally, where the roller will roll irregularly and therefore accommodate itself to the oblong hole. For that reason I believe after a flue sheet has received three or four sets of flues that the use of the roller, even lightly, will insure better work than the use of the prosser expander alone, although in all other cases I would say the use of the prosser expander is best.

Mr. A. N. Lucas—Just a few words, to show how much a flue expands. We were unfortunate in the roundhouse foreman having his man fire up two or three engines without any water in them, and upon inspection I found four or five flues with the bead sticking right out straight, while with the balance of the flues the bead was up against the sheet. On close inspection I found these flues were stopped up and the heat didn't get through them, the balance of the heat going through the rest of the flues pulled this bead right out straight, and when the boiler cooled off the bead was still out.

Mr. Bennett—The Boiler Manufacturers' Association, in their rules covering flues, have one provision stating that a flue should be rolled tight and no more. I believe the tendency of applying flues with air is to overwork them. When a man is doing it by hand he knows pretty nearly when a flue is rolled enough or expanded enough. Now when he uses an air machine he does not realize how much rolling the flue is getting. The same is true when he prossers the flue with a long-stroke hammer; the hammer is doing the work, not the man. After a flue has been prossered just so tight and properly beaded, all further efforts along that line will only wear the flue out. I think in a good many cases there is so much work done on the flues when they are applied, that it takes about all the substance out of the flue and nothing is left for the roundhouse men to do. When rolling a flue with air, you will sometimes find a crease 1/32 inch on a side; that means a reduction in the thickness of the flue of 1/32 inch.

What Mr. Lucas says about overworking the flue is very true. You hammer the prosser in there every time flues are leaking—it isn't necessary. All you can do is just to get the flue to the sheet. Further efforts along that line only go to break the unions and destroy your flue sheet.

The idea that this committee has reported about flues leaking on the back end and not on the front end is very true. Just as soon as a flue leaks on the back end, it is up to the boiler maker; or, in other words, it is considered more work. In the front end, as the committee says, all you have got to do is to put an apprentice boy there, if necessary, and roll the flues, and you will never have any trouble with them leaking. It goes to show that heat and the change of temperature in the back end cause them to leak.

I think we are applying flues to-day just as well as they can be applied. The practice on the New York Central is to use the prosser exclusively in roundhouse work, and we have latterly adopted as standard 1 7/8-inch flue holes and use the 15 gage copper and the flue is swedged down; that would give us 1 3/4 inches in the back end, and the flue is swedged straight for 1 inch, and from 1 inch to 4 inches is tapered; it is a tapering swedge.

Mr. Conrath—Flues should be prossered only when applied. When flues have been prossered with a Missouri Pacific standard prosser, as we call it, with a tapered shank on the back to turn the end of the flue to a 45-degree angle, it is then turned the rest of the way with a beading tool and finished. We next apply the pressure, 25 pounds in excess of steam pressure carried. Any flue that shows a leak is lightly rolled. When flues are being applied we use a copper 3/8 inch wider than the sheet, the copper extending into the water side, while the prosser work will close the end of it tightly around the flue so that it is watertight. It is easier to make a joint with the prosser against the sheet by bending the copper over against the inner part of the sheet. Also the sheet should be lightly counter-bored so as to take off the burr on the inner side of the sheet. Then the flues are worked into the center.

We always mark a diamond in the center of our flue sheets. They are obliged to work the flues around that diamond shape first, and then in the center last. You will all admit that no matter how large the stretch, the expansion tool which you are working the flues with will stretch that sheet. Consequently the men will start on one end of the flue sheet and work the flues completely into the other end, the opposite corner. The result is that the expansion has worked into that corner and you have got oblong holes just as soon as your sheet becomes hot and your pressure is on there.

The cold blast every time the fire door is opened will strike the bottom flues and cause them to leak quicker than the others. You begin and roll your flues on the bottom when the engine is warm. You are stretching your sheet every time you roll it. You are not only stretching the sheet but spreading out and enlarging your holes. After that has been done for a dozen times the holes right above that space become oblong. They are not giving any trouble up there; the beading tool will supply it for the time being; eventually the beading tool will not do the business; the boiler maker gets his roller, sticks it in the flue and the tool will not turn because the flue is oblong. The next thing, away goes the pin and away goes the bridge. That should be avoided, not using the rollers any more than necessary.

My method of working flues after they have been out on the road is this: we first use a ¾ taper mandrel, ¾ to the foot; the same taper the roller pin would be. The holes are all round as they come from the shop. The pin can be used for a little while; then use the prosser. Eventually your flue beads have become spongy; you have got to use the roller; then use it lightly or with good judgment; and after you have done that you have got all out of a set of flues that you will get out of them. I have tried the rollers alone, I have tried the prosser alone, and I found that by using the pin somewhat, the prosser and the rollers last and the standard beading tool, that we get better results than any other way of working flues.

We find when we are applying the flues that we have got perhaps half a dozen different size holes in the front sheet. In order to make a standard swedge, maintain that swedge and the standard tools, we fill these holes out with different size coppers; we start with a No. 14 gage down to a No. 10, then enlarging the copper as the hole becomes bigger, and maintaining the same size swedge, which is 1⅞. We generally allow 3/16 inch strong for bead. If necessary, on the bottom we sometimes allow a little bit more in order to brace the sheet.

The thickness of copper is No. 14, which is 40 pounds, from that down heavier. No 14, 13, 12, 11 and 10. No. 10 is a 70-pound copper. They differ 1/64 inch every number. Where there are different size holes we fill out the holes with different size copper. We always maintain the same swedge.

There is one more thing in regard to leaky flues. All the boilers in the land won't keep flues tight if you do not keep the nozzles and steam pipes tight. Trouble with the front end makes the flue trouble at the back end. Follow up leaky steam pipes and watch them closely.

Mr. D. A. Lucas—My experience has been that the best results are obtained with the prosser expander. The roller ought to be left to the judgment of the man in charge. Referring to the recommendation of the committee, there is one thing in particular to which I would seriously object, and that is grinding the boss off of the expander. I think that is doing away with all mechanical part of working the flues, making a tool that is entirely out of mechanical lines.

I am getting good results out of flues with a wide copper, which I would recommend by all means, and I would also recommend not lighter than a 40-pound copper, something that will stand the tension on the joint, put inside of the sheet.

Mr. Filcer—There have been some remarks made here relative to flues stopping up. Some months ago we adopted 1⅞-inch holes, in the place of 2 inches, in order to increase our bridges and get a little more water around the flues, and since that time we find we have no stopped-up flues, and we also find we have less leaks with the 1⅞-inch hole than we did with the other.

Mr. German—A little over a year ago, on the Lake Erie & Western, they were having considerable trouble with their flues leaking. As it is a bad water district, I asked the privilege of putting in a flue in a certain way. The bridges that were in the sheets at that time were only ⅝ inch. Reducing

A. N. LUCAS, THIRD VICE-PRESIDENT.

the flue from 2 inches down to 1⅞, gave a little better water circulation there and we kept the rolls out of the flues entirely. We didn't even use a pin to fasten them in the sheet. Instead of using a pin we used a straight expander to fasten the flues in the sheet, then we would bell them out with a flaring tool, then put in the recess prosser and prosser them, turn it a few times, that would turn the flue over sufficiently to put the beading tool on and calk it. By that method, leaving the flue below its original size in the application, we increased the mileage on that road from ten to thirty thousand miles.

In regard to cleaning the flues, this flue acts almost the same as a reduced nozzle; it creates a kind of a vacuum that just simply cleans the flue out. We don't have one, I will say, where we formerly had ten flues stop up since that system was adopted. This has been adopted now nearly all over the New York Central lines. I advise using the prosser from the beginning to the end. Since we have adopted the sectional expander, we do not have one roll out of twenty that will hold in any sheet.

Mr. Brown—The swedge which Mr. Bennett refers to, I feel is practical, so far as a swedge is concerned, but I would like to ask why we can sit here and advocate a copper ferrule ¾ or ⅞ inch wide? What use have we for it? You have got no use for that copper underneath the bead of your flue. We are swedging a flue here in order to give a better circulation of water; but we are putting a copper in there that will turn its nose up, and it is a mud-catcher, in my judgment. I feel that a copper ferrule ought to be only slightly in excess of the thickness of the sheet. One great point for criticism—there has been advocated 3/16 inch for a bead. What are you going to do with it? My judgment is not to exceed ⅛ inch of flue for a bead. Our flues are No. 10 gage. That may sound rather heavy to some of you. Some, I presume, are using 12, and some less, but our standard is No. 10. Taking ⅛ inch of this No. 10 gage flue for the bead has given us good results. The least done with a flue bead, or the nearer that we can get the bead of a flue turned over, the better it is for that bead. Avoid crystallization by the use of the hammer in turning the bead. The prosser expander gives you a good start. Get it over nicely and when you get it over there let it alone.

Mr. Laughridge—I am in favor of the prosser expander

W. M. WILSON, FOURTH VICE-PRESIDENT.

for roundhouse work; use the prosser expander all the time, with the exception of setting the flues, to give a light rolling after the flues are expanded. There has been a great deal said about what causes flues to leak. We all say bad water; we admit that. But why in bad water more so than in soft water? When we heat the flue it raises up in the center, because the heat is greater on the top than on the bottom, causing the flue to take a leverage on the inside top of the hole, which crushes the flue, pushes the top of the flue out, and pulls the bottom of the bead off. Now when that flue contracts, the bottom will stay out there and also the top bead will not come back to its original position, but this has shoved against the copper, and every time it expands and contracts it keeps shoving on the copper. Now my experience is, that the bottom of the bead gives out first, for the simple reason that it is straightened out, while the other is just pushed away.

Mr. A. N. Lucas—On a flue from 15 to 16 feet long, before the flue would take that permanent set right next to the sheet, it would come up in the middle, the weight of the flue from holding your crown that way would bag that much, and I do not think it would fall away from the sheet when it has all the chance in the world to give in the middle of the boiler.

Mr. Conrath—Is it not a fact that water leaves the sheet when the engine is working hard; that half of the water will not adhere to a hot sheet? I have seen that demonstrated at Milwaukee pretty well, to my satisfaction; that an engine working, especially where the bridges are small and the body of water small and the sheet becomes hot in the back end of the flues, that the water does not adhere close enough to the sheet. A great amount of our troubles with alkali water, I believe, lays in that; the water will leave the sheet momentarily and the flues become warm; in a little while it will loosen the hold.

Mr. McKeown—Where do your flues start to leak first?

Mr. Laughridge—The lower flues.

Mr. McKeown—Why should they leak there first?

Mr. Laughridge—My experience is, that the flues up in the central part of the boiler have a more uniform heat, or have a better chance for contraction and expansion than the flues at the bottom. The boiler is fed and the water goes down below, which keeps the bottom of the boiler, the shell of the boiler, cooler than the top of the boiler, but the bottom flues are closer to the fire than the top flues; therefore they receive the greater heat with a cooler shell closer to them than the flues at the top of the fire-box.

Mr. McKeown—Why should the flues leak so much quicker in a shallow fire-box than they would in a deep fire-box?

Mr. Laughridge—For the same reason.

Mr. D. A. Lucas had several samples of flues which were supplied with different sized copper ferrules, and in exhibiting them he called attention to the advantages of using a wide copper. He showed that the joint at the inside of the sheet is the best joint on the flue, since when cold air first strikes the flue the joint in the hole contracts, and unless there is a good joint between the copper and the flue at the inside of the sheet the flue will begin to leak. He also described his method of putting in the copper and working the flue as follows:

I put the flue, a dry fit, into the copper and I pin it out with a taper pin; the man drives in a slow taper pin to get the uniform length of his bead, then he expands it, then he rolls it lightly by hand. I wouldn't, under any consideration, take an air machine into a fire-box end. That ought to be entirely done away with. In working the flue don't pound the bead over, turn it over, use the life of it by turning it over. My expander leaves it in that position. I have a standard beading tool that calks it from that position, and I maintain the thickness of the flue all the way around, in addition to increasing the thickness right on the heel of the bead, where we want the strength.

Mr. Brown brought forward a new reason why the bottom flues leak rather than the top ones. He claimed that it was due to the spark arrester in the front end. He showed how the vacuum existing just back of the exhaust makes an eddy and causes the sparks to lie practically immovable, so that the only way the sparks can be extracted is by a rake at the hands of the roundhouse man. These cinders prevent the hot air from passing through the lower tubes, and, therefore, these tubes do not get the benefit of the expansion which the other tubes do, so that they are not so tight. Mr. Brown also deplored very strongly the condition of things at the ash-pit and roundhose, claiming that much of the flue trouble is due to ignorant and careless work at these places.

Mr. A. N. Lucas corroborated Mr. Brown's remarks, giving an instance of how he was able to practically stop all trouble with leaky flues when he was made roundhouse foreman with full charge of things in the roundhouse, and at the ash-pit.

Mr. M. O'Connor stated that he had obtained much useful information from the discussions of the flue question at meetings of the Master Boiler Makers' Association, much of which he had been able to apply with good results, but he had found that where one process would work in a certain place, in different localities it would be of very little use, and he concluded that the conditions under which the boilers are to be operated, that is, whether there is alkali water, etc., would very largely determine the best method to be used in flue work, it being impossible to law down any one hard-and-fast rule to suit all conditions.

Mr. T. P. Madden—Leaky tubes are caused by uneven temperature. The parts of a boiler near the fire door are more exposed to uneven temperature. Supposing we move the fire door from the bottom of the fire-box up to the top. Then your bottom flues would be exposed to an even temperature, and your top flues would leak then in place of your bottom ones.

So I think this is caused more from uneven temperature than anything else.

Mr. Roesch—I think Mr. Madden hit the nail on the head when he said that flue leakage in the bottom flues is due to the position of the fire-door hole. If the diaphragm had anything to do with making the lower flues leak, why did the lower flues leak in the old diamond-stack engines that did not have a diaphragm, that had an opening above the petticoat pipe and one below it? They leaked just the same. I wish to emphasize the fact that it is cold air that makes our flues leak, and we get cold air in the flues every time we wash the boiler.

Mr. Conrath—I believe it would be wise for this convention to make some recommendation. Recommendations from this association should go to our people to treat the water in all bad water districts, to provide better care of engines over the cinder pit, and a little better care on the road. Our troubles are, principally and wholly, solely in this bad water and the misuse and abuse of the engine. Now if that can be overcome, and we can do something by making such recommendations, I believe that our troubles will be partly eliminated.

Mr. Gray—We have found that we get at least 25 percent more service out of flues, and 300 and 400 percent more service out of fire-boxes with a narrow box that sets on the flange, than we do with the wide fire-box, and we have a bad water district.

Mr. Raps—It seems to be the sense of the convention that the prosser expander is the only tool to set flues with. We apply our flues with a beading roller, and we cut down our time from 40 to 24 hours in setting the flues in our largest class engine. We had one failure in March, one in April; we have had none so far in May. Now it looks to me as though there is some other tool beside the prosser in applying flues.

Mr. M. O'Connor—We ought to adopt some paper that we can present to our superior officers so that we could get them to use their influence and good offices; use urgent means to overcome the clinker-pit problem, the blower ash-pan trouble, and matters of that kind.

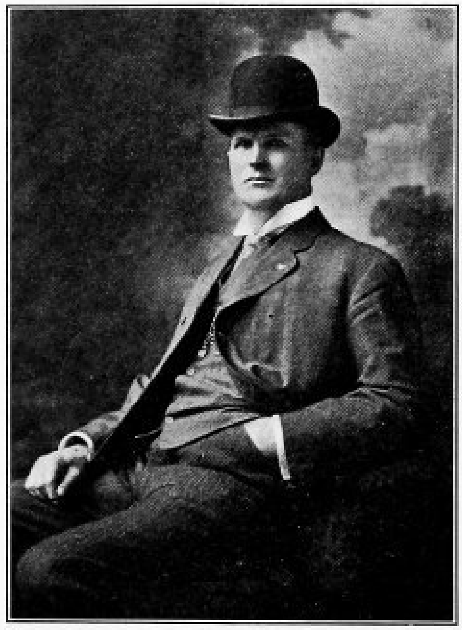
The President—I claim the subject is not in condition yet to go before our superior officers. We ought to have this committee extended, I think, or accept the report which we have, and continue the committee, not discharge it, and see if this committee cannot, during the next year, get these different methods from each of you men in writing, and also sketches of your different methods of doing this work, and then perhaps we would have a hard time deciding which was the one, but we could present to our superior officers a whole lot of methods of doing this thing, and give them an opportunity of taking their pick.

Mr. F. M. White (general mechanical engineer of the New York Central lines)—I have been listening to the discussion, and it occurs to me that your difficulty is in trying to determine what is the best method of setting tubes. I think that you cannot determine what is the best method for setting tubes for all railroads, and I think that your duty should be more along educational lines, and putting on record in your proceedings the different methods which are satisfactory. One method of doing tube work on one road will be satisfactory, and another method will be satisfactory on another road. Perhaps if you would reverse them they would still both be satisfactory, but not necessarily so. Now it would be impossible for you or anybody else, I think, to determine what is the best method for setting tubes on all railroads. You should put on record, I think, the methods that are found satisfactory on various railroads, and I think the duties of your committee then will be of such a nature that they can fulfill them.

At the close of the discussion, it was voted that the committee on boiler flues be continued over to next year, and that they, in the meantime, make recommendations regarding the best methods of doing this work.

Boiler Explosions—Their Cause and Remedy.

An excellent paper was presented on this subject, by Mr. J. T. Goodwin, calling attention to the fact of the responsibility which is placed upon boiler makers to-day on account of the immense size of the boilers which are built, and the



G. W. BENNETT, FIFTH VICE-PRESIDENT.

high pressures which they are designed to carry. He stated that probably nine-tenths of the explosions which occur are due to the neglect or oversight of someone, usually of those in charge of the boiler after it has been built. He described the results of the experiments made by Professor Thurston, at New York, showing that the difference in temperature in adjacent parts of a boiler causes excessive stress on some of the plates and braces, and that this difference in temperature is due to the difference in temperature of the feedwater at the bottom of the boiler, and the steam at the top, while the temperature of the gases outside the boiler is much greater near the fire than at a point where the gases enter the uptake.

Mr. Goodwin explained that boiler explosions were due to four causes: First, defective design; second, poor construction; third, decay of the structure with time; fourth, negligence in management while the boiler is in operation. He brought forward statistics compiled by the Hartford Steam Boiler Insurance Company, to show the number of explosions of stationary boilers, the number of people killed and injured, etc., during the last twenty years; and also statistics from Poor's Manual, showing the number of explosions of locomotive boilers, due to different causes during the last ten years. The average number due to failures of the crown sheet per year is 3.7; due to collision, 1.6; due to derailment,

.3; due to flue failure, .4; the number of persons killed per year, 5.5; injured, 9.6.

Speaking of remedies, or preventive measures, Mr. Goodwin called attention to the modern tools, such as pneumatic drills, reamers, etc., with which accurate work can be done without harming the plates. He also showed that by the use of heaters, laps and corners can be laid together without excessive hammering, which is liable to produce crystallization of the steel and subsequent failure. The modern double-strapped butt joint was illustrated in comparison with the old style lap joint, showing how the plates could better withstand internal stresses with this style of joint.

The report of the committee was accepted and the subject opened for discussion.

Before proceeding with the discussion, however, the secretary presented four new names for membership, stating that

J. T. GOODWIN, CHAIRMAN, EXECUTIVE COMMITTEE.

there had been a total of 41 new applications during the year. Also the report of the auditing committee was read and accepted.

Mr. Roesch discussed very thoroughly the question of why a stay-bolt breaks. He had found, from numerous inspections, that it was difficult to tell by the hammer test when a stay-bolt was fractured. It is easy to tell when the bolt is entirely broken, but he found that many bolts were passed by the inspectors which really were badly fractured. The fractures did not extend to the ⅛ or 3/16-inch telltale holes, so that they could not be detected. He found that almost every one of the bolts broke from the bottom, while every throat sheet brace showed the fracture to begin from the top. This shows that the breaking of the bolts could not be due entirely to the upward movement of the fire-box when heated. In fact very little is really known of what goes on in a locomotive boiler when in service. He claimed that it was erroneous to assume that the bolts were broken, due to the vibration of the bolt, caused by the heating up and cooling off of the fire-box, since the number and magnitude of these vibrations is far below what a bolt will stand in a testing machine. One reason for the breakage of bolts might be the deterioration of the iron, due to the heat, although this is indefinite. From examination it seems very likely that the breakage is due to a vibration, but the cause of the vibration is not plain. Mr. Roesch did not believe that it was due to the heating and cooling of the fire-box at all. He advanced the opinion that it might be due to the pulsation going on in the locomotive boiler when the engine is working hard; that is, the amount of steam that is drawn out momentarily decreases the pressure in the boiler, causing a little upward movement in the fire-box and an outward movement in the shell, which would have the tendency of causing the throat sheet to move up and break the throat braces from the top and break the stay-bolts from the bottom; for this reason he advocated greater steam space in the boilers.

Mr. Bennett—In case of low water would you recommend the engineer to put water in the boiler?

Mr. Roesch—From the tests that have been made by the United States government in trying to explode a boiler by injecting cold water, I do not believe there would be any serious damage except the crown sheet coming down, unless it would be a case where we had quite a number of fractured bolts, in which case there is quite liable to be an explosion.

Mr. Bennett—What I want to bring out is, that the United States government made an experiment, in the course of which they put a hole in the crown sheet and got the crown sheet red hot, and then put cold water right on the crown sheet, and there was no explosion. Regarding the breakage of stay-bolts, there is no question about what breaks stay-bolts on our old side sheets. The expansion works from the center out. You will always find the broken stay-bolts at the corners. Now they are putting in flexible stay-bolts at these points. In the center you do not find as many broken bolts.

Mr. Gray—In the last five years I have examined five boilers that have exploded, and they were practically all from the same cause; the immediate cause being low water. The water in all five engines wasn't more than 2 inches below the highest point in the crown sheet, and not more than two-thirds of the crown sheet was exposed at the time it let go. None of those boilers was over three years old, and two of them were less than eight months old—all new high-pressure boilers. The fire-boxes were literally torn out of four of them, and the fifth one was blown all to pieces. My conclusions regarding the effect of low water are as follows: In all these cases the crown sheets had a certain pitch; none less than 2 inches. It seemed to me that when the water got down and those sheets became overheated, either from stopping or starting, or the engine righting itself in getting around a curve, the water flowing back on this overheated portion of the crown sheet was evaporated into steam instantly, causing a tremendous over-pressure. I have never yet in all my boiler experience seen a boiler entirely explode where the crown sheet was properly stayed. I have seen lots of damaged crown sheets, but nobody has ever been hurt, and the boiler has never entirely exploded. I have seen cases where button-head radial stays have held a damaged crown sheet when the stays which were simply screwed in were pulled out. I have never found any of the button-head stays broken, but the radial stays immediately on each side of them, even up to 22 inches long, are found to break in the same place that the ordinary stay-bolt does, right next to the outside seam.

I have come to the conclusion that when you deflect a piece of iron or steel you are bound to open the pores to a certain extent and allow the impurities which are in suspension in the water to be forced into these openings, starting corrosion. Our bolts are more eaten off than they are broken off.

Upon being questioned, Mr. Gray stated that while low water was the immediate cause of the explosions in the five cases cited, low water will not necessarily cause a boiler explosion every time it occurs.

Mr. Robinson (locomotive boiler inspector of New York State)—About two years ago, in May, 1905, they passed a boiler inspection law in New York State. This required the inspection of all locomotive boilers once every three months. Now, this inspection is not done by the State. The State merely supervises the inspection and the railroad companies employ their regular inspectors, who sign certificates. Of course the State depends on you gentlemen, who are in New York, to see that the work is properly done. We can only give you rules which we believe are fair, but you are the people who must carry out these rules. These rules apply to a little more than 6,000 boilers which operate in the State of New York. These rules have been tried out; they are nothing new with us; they are merely the rules of the railroad companies themselves, and, of course, they should bring good results.

We have had very few accidents. Last year we had from the 6,000 boilers seventeen accidents of all kinds. Only three of these accidents, you might say, were boiler explosions. Two men were killed from explosions due to low water; three men were killed from an explosion due to a defective boiler, and there is a question as to the cause of this particular explosion, some saying it was due to stay-bolts and others to a crack which was nearly 6 inches long in the shell. But the principal accidents are caused by the little things. We have a number of plugs blowing out. We have a number of arch tubes bursting; we have some cases of flues which have been rolled in two and fallen down so that the steam comes out, and then the water glass bursting. Those are the principal causes. We have a great many minor accidents in which life is not lost, due to low water, and we believe a great many of these low-water accidents could be avoided if greater care were taken with the water glass and gage cocks. But we will always have low-water cases even with the very best of care. We believe these inspections will do a great deal of good, because the boiler makers want to do what is right. The boiler makers want to fix the work, but a great many times the superintendent—more so the superintendents of motive power —want the engines sent out, and they must go out.

Mr. Laughridge—I do not think that there is a great increase in steam pressure in the case of low water. When the sheets become red hot and the bolts red hot, they just lose their holding power, and the ordinary pressure of the engine pushes it down. Sometimes it causes an explosion, but in the majority of cases it does not if the braces are all right; it will do nothing more than push the crown sheet down until it relieves itself of the pressure.

I have seen cases where the water was down 12 inches before the crown sheet gave away. The six rows of center bolts had ⅜ inch nuts on them, riveted over; those stays melted; they didn't just pull off but they actually melted before the crown sheet gave away.

I cannot see where there would necessarily be excessive pressure there. The ordinary pressure would be enough to push that sheet down after the bolts and crown sheet have become red hot, because they have no holding power.

Mr. A. N. Lucas—In all our reports of low-water cases we never had any report that the cocks were continually popping or the gage showed excess pressure. And I believe that the sheets seldom become red hot, only where there is a slow fire and no water. The damage done generally is according to the condition of your fire. If you have a heavy fire and low water, no pressure—slight damage. If you have a heavy fire, no water, high pressure—great damage. But any time you can get water under that sheet before it comes down you strengthen the sheet. And I would say that it is the proper thing to do at any time, to get water under the sheet and strengthen it as soon as possible.

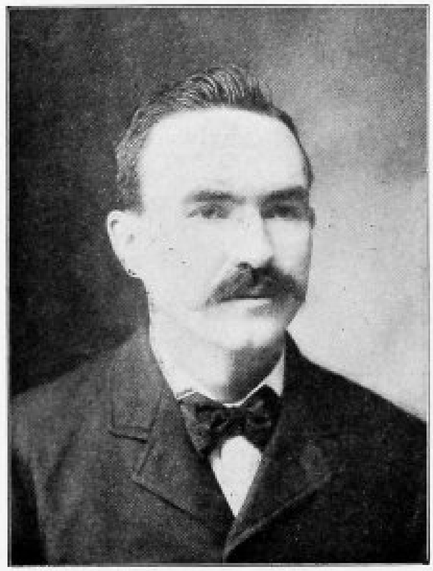
Mr. Gray explained that in all the cases which he had previously mentioned the water didn't exceed 2 inches below the highest point of the crown sheet, and the crown sheets were all of the same construction—radial stays without headed bolts. In all these cases it was not a matter of a damaged crown sheet, but of an exploded boiler.

It was voted that the discussion of the subject of boiler explosions be continued at the next session of the convention, after which the convention adjourned until Thursday morning at 8:30 o'clock.

THURSDAY MORNING SESSION.

President Wagstaff called the meeting to order at 8:50 o'clock, and called on Mr. C. L. Hempel to resume the discussion of the subject of boiler explosions.

Mr. Hempel—In the debate yesterday some of the members thought that possibly we should have made some recommendation as to whether it would be advisable for engineers to put water in the boilers after the crown sheet had become warm. Personally, I would say that when a crown sheet becomes



FRANK GRAY, TREASURER.

overheated there is no danger in putting water into the boiler, for the reason that in putting cold water into a boiler the temperature cannot be increased; it must be decreased by the application of cold water. The only danger that you would encounter would be in not knowing that your crown sheet would stand until you had sufficient time to fill your boiler with water and recover. This must be left to the judgment of the engineer, and if we were to touch on that point it would be better for us to say for him not to put the water in but simply proceed to put out the fires and to try to overcome the difficulty which he had gotten into by letting his water get below his crown sheet.

So far as boiler explosions are concerned, to my mind there is nothing mysterious or mystifying about them. The causes are all natural. In all that I have examined in the past thirty years I have been able to positively state the cause. The majority of cases have been attributed to low water. The engineers have been holding for several years past that the riveted-over crown bolt is not sufficient. The factor of safety, I believe, of the riveted-over bolt is about 11, and of the crown bolt with a large head about 20. If water is kept over the crown sheet, riveted-over crown bolts are perfectly safe, and the large head on the crown bar will not hold the plate if it becomes overheated. Of course, any bolt that is screwed into the plate loses a percentage of its factor of safety as it gets older. Theoretically, when a stay-bolt is put into a plate and remains in service for a time, there would be a great strain upon the plate. I disagree with that; I say that there is no strain; that the plates are under compression while hot, and press together and buckle outward. When the boiler cools off and the plate contracts, the plates are under tension. So it would naturally follow that there would be more danger of the cracking of plates as the boiler was cooling than there would be while the boiler was warming up. And there would be less liability of a serious rupture while under pressure unless it were an over-pressure. The fact that boilers give way under a less pressure than the hydrostatic test shows that the danger is not so great while the boiler is under full steam pressure and the boiler perfectly warm. The contracting and expanding of the boiler cuts but little figure, unless the plates have been deteriorated.

I personally think that the majority of causes of boiler explosions are due to negligence on the part of those in charge. We have had a few cases of improper inspection, such as the case of the gunboat *Bennington*.

HARRY D. VOUGHT, SECRETARY.

Vice-President Wilson called attention to the fact that the factor of safety is lowered when the plates and stay-bolt heads become overheated, so that the boiler cannot withstand the ordinary working pressure. He also said: In the last five years I have examined possibly 250 explosions on other railroads, stationary plants, and on steamboats, and I find that where the boiler has been standing still, neglected for some time, you will find the water down a great deal lower in that boiler than one that has been in use where water has been coming back and forward, where it is not liable to be neglected so long. I find that where a boiler has been standing still, and the water has gradually come down, you will find a decided water line, very easy to detect. In a locomotive boiler this water line is not so easy to find, because, due to the water surging back and forth, it does not have a chance to temper the steel as it is coming down, and cause that fatal blue-heat mark that we look for.

After making a thorough examination of a boiler inside and out and applying a hydrostatic pressure, we should take off the dome cap and get into the boiler, if possible, in order to ascertain if the hydrostatic test has broken any braces or fractured any part of the boiler inside. I have found in the worst cases of boiler explosions that there have been no headbolts in the center of a crown sheet on locomotives. The heads were simply riveted over.

Another thing I find, is that the water glass and the gage cocks on stationary boilers, and very often on locomotive boilers, are neglected. Not only are they likely to be filled up with sediment but very often it is due to the fact that the machinist in putting the water glass in has squeezed the rubber down to the bottom of the gasket; and then when pressure comes on it bulges the gasket and entirely closes up. We cannot be too careful in our roundhouses or even stationary boiler plants to make a thorough examination of the gage cocks and water glasses regularly. We also want to get all concerned educated to the necessity of keeping the water in the boiler.

I find that corrosion and pitting is very deceiving, and especially inside of the boiler. Mr. Wilson here described an instance of how he made a careful examination of six horizontal tubular boilers which had been inspected by a first-class insurance company, and allowed 100 pounds steam pressure, finding that the boilers had been wasted at the water line by corrosion until the plates were only 1/16 inch thick in places. He also called attention to the blow-off cocks on stationary boilers, citing several cases where the blow-off pipe has blown right out of the blow-off on the bottom of the boiler, on the back end, due to the fact that these pipes had been in there for eight or ten years, and the threads become rusted off. He advised doing away with cast-iron elbows and cast-iron flanges, using instead all malleable pipe and all malleable elbows and tees and flanges, made and tested purposely for boiler work. He also emphasized the necessity of educating engineers and firemen to take proper care of a boiler in service.

If any of us are sent out to examine a boiler don't let us get careless in making our examination. You have got to be careful. And when you make an examination of an explosion you want to remember that there is always a chance that something else may have happened except the main thing. It may be as plain as the nose on your face that the boiler exploded from low water, but then you want to investigate; it may not be the engineer's fault that the water got low. I find that very often whoever is in charge of the plant will go to work and make changes in the piping of the boiler; they will put valves between the water column and the steam gage. That is bad practice. Very often I find foreign substances in boilers. I have seen as much as 6 inches of mud and scale in the back end, while everything is perfectly clean around the front manhole. We should see that these boilers are examined at least once a month by our inspector, and when a boiler is washed out, get in there and see that everything is all right.

Do not make any changes in the design or arrangement of a boiler unless such changes or improvements have the approval of the inspector or headquarters. I found one case where a man changed the design and took out the fine braces that were applied when the boiler was built and put on little straps in there. The result was that we had a crown sheet come down, all due to the fact that a man took it into his mind to change that design. Look out for the water in the locality where the boiler has been used; it may cause pitting and corrosion, and also look out for bad boiler compounds. On stationary boilers we ought to insist on the safety valves being sealed. This is not so necessary on locomotives, because of the fact that everybody should be honest and obey the company's rules; but on stationary boilers, where we have more ignorant and incompetent men around the boilers, I think that the safety valve should be sealed.

An inspector of stationary or locomotive boilers should be a man of experience, and a man that has conservative, broad-minded views in everything. I know there are a great many men testing stationary boilers that have never built a boiler, never driven a rivet, never calked a seam; don't know what it is to put in flues, don't know what it is to flange a patch, don't know how much heating or pounding it is taking to put a patch up in a certain way. A man that inspects stationary boilers should be a man who has been through all that and understands it. I don't care how much technical knowledge an inspector has and what he knows about a steam plant, he should be a practical boiler maker in order to appreciate just what the boiler will do and what it will not do, how it is designed, how it is abused, how we cover up the different defects and how to look for them.

Mr. Roesch—I wish to emphasize the fact that our hammer test is not absolute for finding a broken bolt, a dead bolt. Very few men can locate all the fractured bolts, especially if the fracture does not extend half-way through the bolt. Our telltale holes do not "tell tales" in all instances. As the stay-bolts that I found all started from the bottom, it would be a good idea in making your hammer test to hit the bolt on the top and hit it on the bottom. In that way you will be more apt to find a fracture than you would by just hitting the bolt haphazard.

It was voted to close the discussion and continue the committee another year.

Best Method of Applying Flexible Staybolts.

A paper on the subject of applying flexible stay-bolts was presented by Mr. R. V. Anderson, assistant foreman at the Rogers Works of the American Locomotive Company, Paterson, N. J. This paper described the method in use at the Rogers Works, leaving the subject open for discussion. Mr. Anderson pointed out the fact that the main requirement for successfully applying flexible stay-bolts is good judgment, since a careless or injudicious workman can spoil a job, even though he is supplied with perfect tools, perfect bolts and perfect holes. The holes in the sheet are punched 1/32 inch smaller than the diameter at the root of the thread at the point of the sleeve, and reamed with a taper reamer which goes through and is guided by the fire-box sheet. A stop, fastened on the reamer, prevents the reamer from going in too far, and allows 3/32 inch for the thread, making all holes exactly the same size. The tap also has a guide and stop, so that all holes are tapped the same. The sleeves are screwed in with a stud nut driven with a ratchet lever, the bolts are run in with an air drill until they are nearly home, then adjusted carefully by hand, so as to get an equal load on each bolt without pulling the fire-box sheet out of line. A special device is used at this shop for holding on the bolts while riveting. It consists of a nipple, which is screwed on to the sleeve, and has a sliding plunger inside which fits on the head of the bolt; the holding-on is then done by a common sledge which backs up on the outside end of the plunger.

It was voted that the body of this report be placed in the proceedings, and the subject passed along without discussion.

Shall a Committee be Appointed on Senate?

The president explained that this subject was brought up for discussion, because about a year ago a bill was prepared to go before the Senate of the State of Illinois in reference to boiler inspection, and it was suggested that it would be a good thing for this organization to take an interest in this bill. Inasmuch as the subject was an important one, and the members were not fully informed regarding the provisions of this bill, it was voted that the subject be continued until the next convention, and that, meanwhile, copies of the proposed Senate bill be secured and mailed to the members, so that the subject could be taken up and discussed in a thorough manner.

Proper Preparation and Presentation of Subjects and Papers.

Mr. J. H. Smythe presented a paper setting forth the methods which had formerly been used in preparing papers for discussion, showing wherein these methods had failed to bring about the desired results, and proposed a new scheme for this work. He said that the idea of appointing committees was to have the subject thrashed out by competent men during the year, so that at the time of the convention the committee may present a paper which shall contain a digest of all the information which can be brought to bear on the subject in such a form that the results of the investigations can be adopted by the association. He stated that there were many subjects which could not be disposed of at one convention, as, for instance, rules and formulas for building boilers. Such subjects should be carried over from one convention to another. The speaker suggested that in future when a committee is appointed, the chairman write to the members of his committee, asking them to submit their views on the subject; the chairman then taking the data from the letters received and condensing the information into one paper. This paper could then be mailed to each member of the committee for approval or suggestions, revising the paper as many times as necessary until the paper is satisfactory to every member of the committee. After the paper is completed by the chairman, he should then forward it to the secretary of the association, so that it can be sent out in advance form not later than sixty days before the annual convention.

In the discussion which followed, the secretary pointed out that nothing would contribute more to the success of the organization than the prompt and systematic handling of subjects, and their presentation upon the basis suggested by the author of this paper. He suggested, however, that the paper be slightly modified to overcome some of the difficulties which he had encountered in his long experience in such matters. These suggestions embodied the following ideas: First, that the committees shall be limited to three men on a subject; second, that the members of the committee place their views in the hands of the chairman not later than sixty days in advance of the convention, making it possible for the chairman to prepare his report, send it to the members of his committee, and obtain their concurrence or disapproval, the statements of why they disapprove forming a minority report to be in the hands of the chairman within thirty days. The report then to be sent to the secretary, who will be able to get advance reports in the hands of every member of the association in ample time for them to become thoroughly familiar with the subject which is to be presented before the convention.

After some discussion, the recommendations embodied in Mr. Smythe's paper were referred to the committee on constitution and by-laws.

The president then introduced Mr. Eugene Chamberlain, of the New York Central Railroad, who made a short address, complimenting the association upon its work, and stating that only by meeting together and dispersing knowledge, as the association is doing, can it hope to obtain successful results and results which will be of benefit to the industry.

The President—The next subject on the programme is "Standardizing of Shop Tools," to be opened by T. C. Best. This is also an individual paper, with a view of bringing this subject before the convention to see if they desire to have a permanent committee on standardizing tools to report each year to the convention so that we can be kept posted in regard to what new machinery or tools are coming into use in our business.

Standardization of Boiler-Shop Machinery and Tools.

This paper clearly defined the sort of standards which the association is free to adopt; that is, it can adopt standard rules for the strength of boilers or tanks; standard specifications for material; standard methods of developing an oval, etc., but it cannot adopt any particular make of machine and say that that shall be a standard. It was claimed that the progress of the association would be measured by the work of the committees in establishing such standards. The great necessity of having such a standard is clearly shown in the instance of one particular line of tools, viz.: punches, dies and couplings. There are at the present time six different standards which have been adopted by individual manufacturers for punches, dies and couplings. It is very evident that if one standard covered all these tools, such supplies could be ordered from any supply house in the country, by means of numbers, without the necessity of supplying sketches and dimensions.

Vice-President Wilson—I believe that it would be well for this association to work with a view towards getting out standard regulations from time to time, and I believe we should have a competent committee, as suggested by Mr. Best. I believe it would be a good idea if we could have one book published by this association, with all our standards, kept in a condensed form in this book, similar to the master mechanics' proceedings. I believe if this standard committee could go along in a broad and conservative way, as outlined and put in condensed form, with drawings, etc., showing any tool that is gotten up, standard beading tool or fullers, or calkers, or expanders, or rollers, that that book would be referred to when our officers want to get up some new design or order some new tools, and I would be very much in favor of having a committee appointed to recommend these subjects and different articles, and have them put in proper form in our proceedings or in a special book, so that we could refer to them readily and quickly.

It was voted that a committee be appointed, and that Mr. Best's paper be accepted, also that this paper be referred to the committee that shall be appointed.

The next matter of business taken up was the report of the committee on amendments to constitution, which was presented by Mr. Laughridge.

The articles of this report were taken up and discussed separately. As finally adopted the amendments to the constitution were as follows: The officers of this association shall consist of a president, first, second, third, fourth and fifth vice-president, who shall be active master boiler makers, assistant foremen or general boiler inspectors, and engaged as such at the time of election; a secretary and treasurer.

The executive committee shall consist of nine members in place of five.

The executive board shall be elected by ballot set forth to elect their chairman who is to serve during the term of his incumbency, the members of the board to serve as follows: Three members, three years; three members, two years; three members, one year. After three years all members will serve three years.

Active members shall consist of master boiler makers, assistant foremen and general boiler inspectors and government, State and insurance inspectors who are practical boiler makers.

It was voted that the report of the committee on constitution and by-laws be accepted with thanks, and that the committee be carried over until next year. Since Mr. Laughridge was the only member of that committee present, a committee, consisting of Mr. Laughridge, Mr. McKeown and Mr. D. A. Lucas, was appointed to act on Mr. Smythe's paper.

Two more new names were presented for membership and accepted, bringing the total number of new members for the year up to forty-three.

Report of Committee on Resolutions.

Your committee begs leave to report in consideration of the manifold matters and individuals that have contributed to our personal pleasure, combined not only to render our brief sojourn in the beautiful city of Detroit memorable but to furnish occasion for grateful remembrance after returning to our homes, and that we herewith formally recognize our special indebtedness for the cordiality with which we have been received in the City of Straits. It was an assurance that we were among friends, and this has been later emphasized by the hospitality accorded. This particularly applies to the finely appointed "Pontchartrain," with its charming attractions, and to its managers, who have so gracefully made our stay agreeable.

Our acknowledgments also to the Supply Men's Association cannot be too strongly emphasized. We are deeply indebted to them not only collectively as an organization but also as individuals for the social enjoyment they have so liberally provided, and which has in no small way contributed to the success of the convention. Their personal solicitation for our comfort and pleasure has been very marked. For this as well as the many other thoughtful courtesies and attentions, we beg to convey our assurance of highest appreciation.

Substantial evidence of the esteem in which our association and its work is held is afforded in the recognition accorded by the technical press. We tender them special thanks for the liberal space and attention given us. We believe it is no more than just to particularly refer to The Boiler Maker and its representatives, as they have done so much to assist in promoting the welfare of the organization.

We note with pleasure the growth of the Ladies' Auxiliary, and the increased attendance in general of the ladies at this, over other conventions. This has contributed greatly to our enjoyment and added prestige to our organization.

We wish to draw particular attention to the very efficient and pleasant manner in which our officers have performed their duties in the past year, and we recommend a vote of thanks be extended to them.

(Signed) C. E. Lester.
W. McKeown.
J. H. Smythe.

As it has pleased our Heavenly Father in His infinite wisdom to take from our midst our beloved brother, R. H. Jackson, of Buffalo, N. Y.,

Resolved, That we the members of the International Master Boiler Makers' Association, convened at Detroit, Mich., May 28, 1908, extend to his bereaved relatives and friends our heartfelt sympathy, and be it furthermore

Resolved, That a copy of this resolution be presented to his bereaved wife and spread upon the minutes of this meeting.

(Signed) C. E. Lester.
W. McKeown.
J. H. Smythe.

THURSDAY AFTERNOON SESSION.

Standardizing of Blue Prints.

In opening the discussion on this subject, Mr. Laughridge stated that while the topic was given as "Standardizing of Blue Prints," the real subject to be discussed was the standardizing of laying out and construction of boilers, which would eventually lead up to the standardizing of developed blue prints and developed pattern sheets of boilers. He did not attempt to specify any definite manner of procedure to be adopted for standardizing such work, but pointed out the advantages which would result from it. It would not only result in more uniform work but would reduce the cost and facilitate repairs. The way the work is done now, each boiler is laid out from a general blue print, and it is very rarely that two boilers built from the same print will be exactly similar in all details; that is, a boiler is built by the "put up and try" and "whittle and fit" method, so that when it comes to replacing any part it is seldom found that there are the same number of holes in the plates as are indicated on the general blue print; whereas, if a set of detailed standard drawings were kept and each boiler of the same class laid out from these, worn out or defective parts could easily be replaced by referring to these blue prints, and the layer-out could be absolutely sure that the part would fit.

Upon being questioned, Mr. Laughridge stated that the various sheets would be laid out in detail on the blue prints in the mechanical engineer's office, showing all the spacing, the cambering and everything.

Mr. Gray—The idea is very good, because then all our boilers made after that blue print would be alike; you could then go to work and make the sheet and put it right into the boiler without any reference to the boiler at all.

Mr. Conrath—This matter comes home to the manufacturers first. We have a number of boilers of the same class of engines, which have been built at different times, supposed to be built from the same blue prints, and when we come to disconnect the shell from the connection, we find one more hole in a certain class than we do in another. The manufacturers ought to be much more careful about that part of it. That is where these blue prints ought to become standard first, so as to build all boilers of the same dimensions with the same number of holes in them. We ought to send that hole question to the manufacturers first.

It was voted that a committee be appointed on the standardization of the laying out and construction of boilers.

Under the head of miscellaneous business, it was voted that in future in securing hotel space and rates the committee shall not exceed $3.50 a day, American plan; that the convention be held four days instead of three, and the hours of meeting be from 8:30 to 1. Also that the time of the convention shall not be limited to the month of May, but shall be fixed by the executive committee.

The report of the committee on by-laws was read, recommending that the paper presented by Mr. Smythe be accepted and turned over to the executive committee, and that each member of the executive committee shall act as a permanent chairman of topic committees assigned to him by the chairman of the executive board.

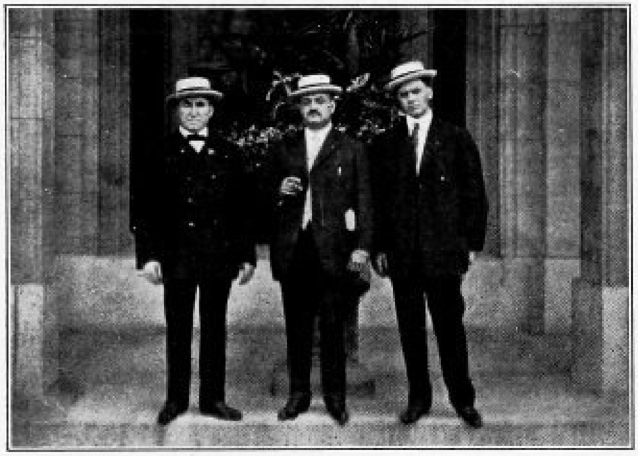
The report was adopted.

After deciding upon Louisville, Ky., as the place of the next meeting, the association proceeded to the election of officers with the following result:

President, P. J. Conrath. St. Louis, Mo.
First vice-president, Arthur E. Brown, Louisville, Ky.
Second vice-president, J. J. Fletcher.
Third vice-president, A. N. Lucas, Milwaukee, Wis.
Fourth vice-president, W. M. Wilson, Chicago, Ill.
Fifth vice-president, G. W. Bennett, Albany, N. Y.
Chairman executive committee, J. T. Goodwin, Richmond, Va.
Secretary, Harry D. Vought, 62 Liberty street, New York.
Treasurer, Frank Gray, Bloomington, Ill.

The following members and guests of the association were present at the convention:

G. P. Robinson, inspector, New York Public Service Commission, Albany, N. Y.; James T. Ward, foreman, Sturtevant Heating & Blower Company, Chicago, Ill.; Miss Ward, Chicago; W. Plowman, foreman boiler maker, Big Four, Urbana, Ill.; Mrs. W. Plowman, Urbana; Arthur E. Brown, general foreman boiler maker, L. & N. R. R. Louisville, Ky.; Hal Howard, foreman boiler maker, I. C. R. R., Jackson, Tenn.; W. G. Stallaings, foreman boiler maker, I. C. R. R., McComb, Miss.; James Bruce, foreman boiler maker, 'Frisco Railroad Company, Kansas City, Kan.; Mrs. Catherine Bruce, Kansas City; Martin Wulfeck, foreman boiler maker, C. & O., Covington, Ky.; Mrs. Louise Wulfeck, Covington, Ky.; F. L. Lothrop, foreman boiler maker, Erie, R. R., Susquehanna, Pa.; Chas. Kraus, foreman boiler maker, Big Four, Delaware, Ohio; W. S. Larason, foreman boiler maker, Z. & W., Axline, Ohio; Mrs. W. S. Larason, Axline; A. N. Lucas, general foreman boiler maker, C. M. & St. P. R. R., Milwaukee, Wis.; Mrs. A. N. Lucas, Milwaukee; Miss Nina Bell Lucas, Milwaukee; Wm. Zelinsky, foreman boiler maker, Central Boiler Works, Detroit, Mich.; Frank Berrey, foreman boiler maker, Erie R. R., Cleveland, Ohio; Wm. H. Hopp, foreman boiler maker, Chicago, Milwaukee & St. Paul R. R., Dubuque, Ia.; Mrs. W. H. Hopp, Dubuque; Wm. Shoemaker, foreman, Hibben & Company, Chicago, Ill.; Wm. McKeown, foreman boiler maker, Lehigh Valley R. R., Buffalo, N. Y.; Mrs. Wm. McKeown, Buffalo; Miss Helen McKeown, Buffalo; R. W. Clark, foreman boiler maker, N. C. & St. L., Nashville, Tenn; Frank Atkinson, assistant foreman boiler maker, Cooke Works, American Locomotive Company, Paterson, N. J.; F. R. Fedler, general boiler foreman, C. R. I. & P. Ry., Davenport, Ia.; H. M. Barr, foreman boiler maker, C., B. & Q. R. R., Lincoln, Neb.; Wm. McLean, foreman boiler maker, Y. & M. V., Vicksburg, Miss.; P. F. Flavin, Western traveling manager, Standard Railway Equipment Company, St. Louis, Mo.; Mrs. P. F. Flavin, St. Louis; J. J. Boyce, foreman, I. C. R. R. Co., Chicago, Ill.; F. A. Batchman, foreman boiler maker, N. Y. C. Lines, Elkhart, Ind.; B. F. Sarver, foreman boiler maker, Penn Company, Fort Wayne, Ind.; R. P. Crimmins, foreman boiler maker, C. C. C. St. L. R. R., Mt. Carmel, Ill.; Clement Ryan, foreman and inspector, Union Pacific R. R., Omaha, Neb.; J. H. Smythe, foreman boiler maker, Rogers Locomotive Works, Paterson, N. J.; Mrs. J. H. Smythe, Paterson; G. W. Bennett, general foreman boiler maker, N. Y. C. R. R., West Albany, N. Y.; Mrs. G. W. Bennett, West Albany; Peter Spence, foreman boiler maker, Canada Northern Railway, Winnipeg, Man.; Thos. Oliver, foreman boiler maker, O. & M. Ry., East Tawas, Mich.; Mrs. Thos. Oliver, East Tawas; J. C. Trefts, superintendent, Farrar & Trefts, Buffalo, N. Y.; C. F. Wilde, foreman boiler maker, M. & O., Jackson, Tenn.; Mrs. C. F. Wilde, Jackson; John McDermott, foreman, I. C. R. R., Water Valley, Miss.; T. A. Henderson, foreman boiler maker, H. O. C. R. W., Bergren, O.; Mrs. T. A. Henderson, Bergren; T. C. Best, salesman, Joseph T. Ryerson & Son. Chicago, Ill.; Dan Coughlin, foreman boiler maker, Erie R. R., Hornell, N. Y.; O. F. Mead, mechanical engineer, Detroit, Mich.; John McKeown, foreman boiler maker, Erie R. R., Galion, Ohio; Mrs. Elizabeth McKeown, Galion; Robt. U. Wolfe, city boiler inspector, Omaha, Neb.; Mrs. R. U. Wolfe, Omaha; Oscar Zappe, foreman boiler maker, D. S. S. & A. R. R., Marquette, Mich.; Mrs. Oscar Zappe, Marquette; M. J. Guiry, foreman boiler maker, Great Northern R. R., St. Paul, Minn.; Mrs. M. J. Guiry, St. Paul; A. C. Dittrich, foreman boiler maker, Minneapolis, Minn.; Mrs. L. J. Porter, Minneapolis; W. H. Cour, foreman boiler maker, Mobile & Ohio R. R., Whistler, Ala.; D. A. Lucas, general foreman boiler maker, C., B. & Q., Havelock, Neb.; Miss Jennie Lucas, Havelock; M. O'Connor, general foreman boiler maker, Chicago & Northwestern, Missouri Valley, Ia.; Mrs. Agnes O'Connor, Missouri Valley; C. L. Hempel, general boiler inspector, Union Pacific, Omaha, Neb.; Mrs. Ella A. Hempel, Omaha; Miss Grace Hempel, Omaha; C. F. Shoemaker, foreman boiler maker, Pere Marquette R. R., Grand Rapids, Mich.; Mrs. Della M. Shoemaker, Grand Rapids; E. W. Young, boiler inspector, Chicago, Milwaukee & St. Paul, Dubuque, Ia.; Mrs. E. W. Young, Dubuque; J. L. Blass, Detroit, Mich.; W. M. Wilson, general boiler inspector, I. C. R. R., Chicago, Ill.; Mrs. Ada Wilson, Chicago; George Wagstaff, supervisor of boilers, N. Y. C., Albany, N. Y.; Mrs. G. Wagstaff, Albany; Miss Ethel Maxwell. Albany, F. P. Roesch, master mechanic, Southern Railway, Spencer, N. C.; John E. Stokes, foreman boiler maker, I. C. R. R., Clinton, Ill.; J. German, supervisor of boilers, Lake Shore R. R., Kankakee, Ill.; Mrs. J. German, Kankakee; Frank Silberman, foreman boiler maker, Lake Erie & Western, Lima, Ohio; E. E. Rapp, chief boiler inspector, Toledo, St. Louis & Western, Frankford, Ind.; M. F. Vizard, foreman boiler maker, Pere Marquette R. R., Iona, Mich.; Samuel Dyke, Lima, Ohio; Alfred Cooper, foreman boiler maker, St. Joseph & Grand Island, St. Joseph, Mich.; Mrs. Alfred Cooper, St. Joseph; C. L. Wilson, foreman boiler maker, I. C. R. R. Co., Louisville, Ky.; Mrs. Jennie Wilson, Louisville; Joseph Joyce, foreman boiler maker, International Ry., Moncton, N. B.; F. J. Howe, foreman boiler maker, C., B. & Q. R. R., Creston, Ia.; Peter Eck, foreman boiler maker, I. C. R. R., Mattoon, Ill.; Wm. F. Besant, foreman boiler maker, I. C. R. R., Centralia, Ill.; M. H. Larkin, foreman, I. C. Ry., Memphis, Tenn.; J. H. Filcer, general foreman boiler maker, Big Four and N. Y. C., Indianapolis, Ind.; James E. Cooke, foreman boiler maker, B. & L. E. R. R., Greenville, Pa.; Mrs. Rose B. Cooke, Greenville; Miss Florence Cooke, Greenville; Henry J. Raps, foreman boiler maker, Illinois Central R. R., Waterloo, Ia.; Mrs. H. J. Raps, Waterloo; Frank Gray, foreman boiler



B. E. D. Stafford.
G. N. Riley. G. R. Slate.
OFFICERS OF THE SUPPLY MEN'S ASSOCIATION.

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Supply Men's Association.

The entertainment features of the convention were splendidly carried out under the direction of the Supply Men's Association. These included a visit to the shops of the Chicago Pneumatic Tool Company on Tuesday afternoon; a theatre party Tuesday evening; a boat ride up the famous St. Clair Flats Wednesday afternoon and evening; and a banquet on Thursday evening. The boat ride was given by the Detroit Seamless Steel Tubes Company, of Detroit, Mich., and the banquet by the Chicago Pneumatic Tool Company, Chicago, Ill. Many handsome souvenirs were distributed by other members of the Supply Men's Association.

At the annual meeting of the Supply Men's Association the following officers were elected for the coming year.

President, B. E. D. Stafford, Flannery Bolt Company, Pittsburg, Pa.

Vice-president, George N. Riley, National Tube Company, Pittsburg, Pa.

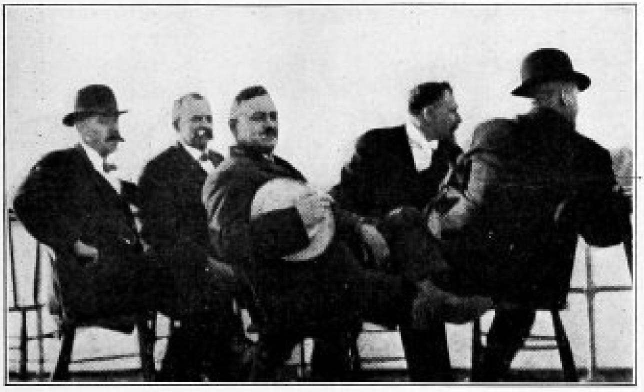
Secretary and treasurer, George R. Slate, The Boiler Maker, New York.

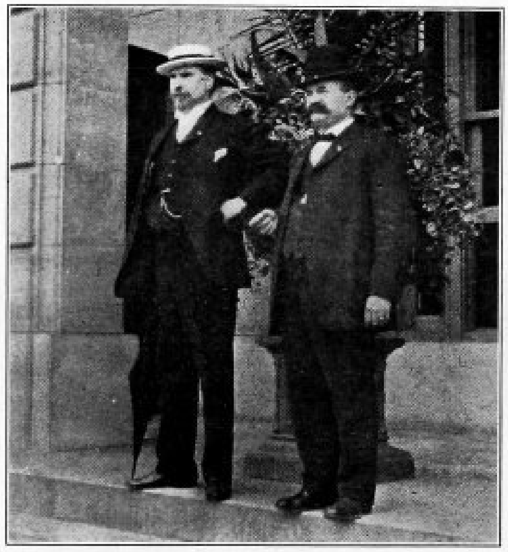
Chairman executive committee, H. S. Covey, Cleveland Pneumatic Tool Company, Cleveland, Ohio.

Chairman entertainment committee, Charles Shults, Worth Brothers, Coatesville, Pa.

The following members of the Supply Men's Association were present at the convention:

W. P. Murphy, Standard Railway Equipment Company, St. Louis, Mo.; B. H. Tripp, Ingersoll-Rand Company, Cleveland, Ohio; Geo. W. House, Otis Steel Company, Detroit, Mich.; H. B. Hove, Otis Steel Company, Cleveland, Ohio; T. L. Dodd, Worth Bros., Chicago, Ill.; R. T. Scott, Independent Pneumatic Tool Company, Chicago, Ill.; Mrs. R. T. Scott, Chicago; Chas. B. Moore, American Locomotive Equipment Company, Chicago, Ill.; R. D. Chapman, Bethlehem Steel Company, Bethlehem, Pa.; E. S. Knisely, Bethlehem Steel Company, Bethlehem, Pa.; Thos. Draper, Draper Manufacturing Company, Port Huron, Mich.; Mrs. Draper, Port Huron; Frank B. Hart, Detroit Steel Casting Company, Detroit, Mich.; C. M. Walsh, Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio; Mrs. Walsh, Cuyahoga Falls; F. A. Murphy, Falls Hollow Staybolt Company, Cuyahoga pany, Chicago, Ill.; O. S. Fluegel, Dearborn Drug & Chemical Company, Detroit, Mich.; G. W. Spear, Dearborn Drug & Chemical Company, Chicago, Ill.; J. C. Campbell, Chicago Pneumatic Tool Company, Chicago, Ill.; W. H. S. Bateman, Champion Rivet Company, Cleveland, Ohio; C. L. Hampton, Parkesburg Iron Company, Parkesburg, Pa.; H. A. Beale, Jr., Parkesburg Iron Company, Parkesburg, Pa.; George Thomas, III., Parkesburg Iron Company, Parkesburg, Pa.; W. L. Kerlin, Henry Pels & Co., New York; E. M. Helwig, Chicago Pneumatic Tool Company, Cleveland, Ohio; J. F. Duntley, Chicago Pneumatic Tool Company, Cleveland, Ohio; C. J. Albert, Cleveland Pneumatic Tool Company, Cleveland, Ohio; J. T. Graves, Cleveland Pneumatic Tool Company,





SNAPSHOTS FROM THE DETROIT CONVENTION.

Falls, Ohio; W. S. Lindsley, Lindsley & Eckliff Company, Detroit, Mich.; Geo. J. Thust, Detroit Seamless Steel Tubes Company, Detroit, Mich.; L. Phillips, National Tube Company, Chicago, Ill.; W. E. Watson, National Tube Company, Pittsburg, Pa.; Thos. Simpson, Detroit Seamless Tubes Company, Detroit, Mich.; C. R. Phillips, Seamless Tubes Company of America, Pittsburg, Pa.; A. C. Morse, Seamless Tubes Company of America, Pittsburg, Pa.; J. G. Talmadge, Talmadge Manufacturing Company, Cleveland, Ohio; E. H. Janes, Talmadge Manufacturing Company, Cleveland, Ohio; R. H. Phillips, Detroit Seamless Tubes Company, Detroit, Mich.; W. H. Armstrong, Ingersoll-Rand Company, New York; H. A. Pike, Flannery Bolt Company, New York; F. E. Lawson, Chicago Pneumatic Tool Company, Detroit, Mich.; R. B. Owen, Detroit Seamless Tubes Company, Detroit, Mich.; C. A. Carscordin, Detroit Seamless Tubes Company, Chicago, Ill.; T. B. Kirby, Detroit Seamless Tubes Company, Chicago, Ill.; George E. Severy, Otis Steel Company, Cleveland, Ohio; C. C. Swift, Cleveland Punch & Shear Works Company, Cleveland, Ohio; F. M. Munger, Mark Manufacturing Company, Cleveland, Ohio; Mrs. Graves, Cleveland; A. Scott, Cleveland Pneumatic Tool Company, Cleveland, Ohio; H. S. Covey, Cleveland Pneumatic Tool Company, Cleveland, Ohio; Mrs. H. S. Covey, Cleveland; C. W. Ellis, Hanna Engineering Works, Chicago, Ill.; W. White, National Boiler Washing Company, Chicago, Ill.; T. Davis, Flannery Bolt Company, Pittsburg, Pa.; J. W. Williams, Brown & Co., St. Louis, Mo.; E. R. Blogden, National Tube Company, Pittsburg, Pa.; E. D. Giberson, National Tube Company, Pittsburg, Pa.; Geo. Hayes, Chicago Pneumatic Tool Company, Detroit, Mich.; F. W. Blume, Scully Steel & Iron Company, Chicago, Ill.; J. W. Faessler, J. W. Faessler Manufacturing Company, Moberly, Mo.; F. E. Palmer, J. W. Faessler Manufacturing Company, Moberly, Mo.; Geo. N. Riley, National Tube Company, Pittsburg, Pa.; Chas. Shults, Worth Bros., Coatesville, Pa.; B. E. D. Stafford, Flannery Bolt Co., Pittsburg, Pa.; Thos. Aldcorn, Chicago Pneumatic Tool Company, New York; George Slate, THE BOILER MAKER, New York; Mrs. George Slate, New York; H. H. Brown, THE BOILER MAKER, New York.

German Methods of Marine Boiler Construction.—II.*

BY PROF. WALTER MENTZ.

On the small sized heads as, for instance, those used in watertube boilers, the calking edge can be easily worked up on either a planing machine or boring mill, but for larger courses and for the tube and back sheets of the combustion chambers of cylindrical boilers the machine, shown in Fig. 9, patented by O. Froriep, machine tool builder at Rheidt, is frequently used. The essential feature of this machine is a wire cord placed around the outside edge of the pieces to be

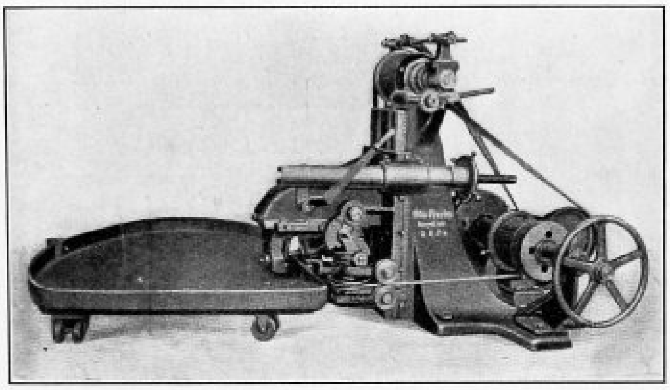


FIG. 9.

worked up and fastened with a clutching device. By winding up the wire cord on a drum attached to the machine, the calking edge of the head, which has been placed on a small truck, will be drawn through the cutting head of the machine, where a revolving cutter is located which can be regulated to cut the edge of the plate on a bevel. The calking edge can also be worked up, as shown in Fig. 10, with an ordinary milling cutter, or it can be chipped by hand with a chisel.

In drilling the holes for the tubes, a small hole is usually drilled first, and then with a cutter of the type shown in

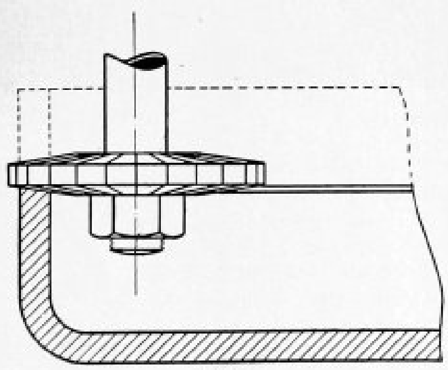


FIG. 10.

Fig. 11 a circular disc is cut out. Frequently the plate is not cut entirely through, but a few hundredths of an inch of metal are left, the circular piece then being driven out with a hammer. With one of the devices patented by the Hettner firm in Munstereifel it is possible to avoid drilling the small centering holes. This is accomplished by placing in the hollow spindle of the drilling machine a movable bar which is turned down to a point at the end, and which does not revolve with the cutter. This bar is forced down and its pointed end is centered in a center punch hole, marking the location of the tube; then the circular cutter is started and operates in the usual way.

In heads which are made with more than one plate, the corners of the individual plates are thinned out, and the length of the thinned-out part bent inwards slightly. After fastening together the separate parts the corners are fitted; that is, they are brought into exact alinement one upon the other by hammering. With the exception of the holes for the girth seams all the holes are then drilled in the heads, the seams themselves riveted and the braces, as well as the reinforcing plates, are riveted on.

The butt straps must be fitted to the curvature of the shell, and holes for tack rivets must be drilled in places where later on rivet holes will be located. The holes for the tack rivets are of smaller diameter than those for the rivets which are to be finally put in. For the more or less exact fitting of the butt straps cold bending will suffice, and for this purpose a special arrangement is frequently fitted on the hydraulic riveting machine. Then the butt straps are fastened with bolts First, however, after the bending of the plates, the rivet holes for the longitudinal seams are drilled simultaneously through the butt straps and the shell plate by means of a radial drilling machine. Punched holes are not used in marine boiler construction, since the plate in the vicinity of the holes is harmed by this rough treatment, although it is a cheap form of construction. With punched holes thicker plates must be used in order to satisfy the requirements of the classification societies, so that any saving in the cost of putting in the holes is offset by the cost of the thicker plates. After the rivet holes have been drilled the butt straps are taken off and the burrs removed. The butt straps are then fitted to the shell again, and any holes which are not exactly fair are reamed out. Also, the rivet holes must be slightly countersunk on both sides, since the rivet head is joined to the shank with a short conical fillet.

After the longitudinal seams have been riveted, the courses are fitted together and the girth seams drilled, after which the courses are taken apart again for the removal of the burrs. In a similar manner the furnaces are fitted to the combustion chambers, riveted up and then placed together in the boiler before the back head is riveted to the shell. Then the stay-bolt holes are drilled and tapped. Finally, the

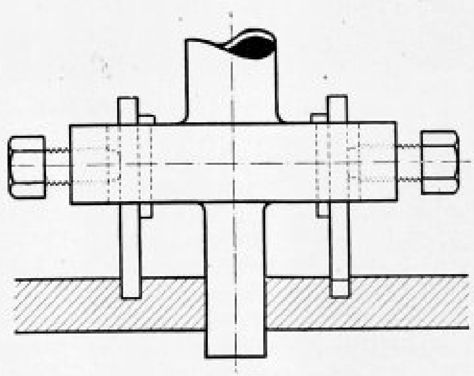


FIG. 11.

stay-bolts, stay tubes, plain tubes and braces are put in, after which the boiler can be subjected to a preliminary pressure test.

The subject of riveting requires special consideration. In the first place, the plates must be fitted tightly together, and then the shank of the rivet itself must be upset so that it completely fills the rivet holes. By cooling, it squeezes the plates together still more tightly. With hand riveting, which is customary on small boilers, and also on large boilers where it is impossible to use a machine, as, for instance, in riveting up the last girth seams, although the plates can be fitted together

* From Schiffbau.

just as tightly, yet the shank of the rivet cannot be so perfectly upset as that of a machine-driven rivet. In the application of the latter, which also saves the plate from abuse, since the formation of the rivet head is accomplished by steady pressure, the thickness of the plates for the boiler shell can, according to the requirements of the classification societies, be taken somewhat smaller. With machine riveting, however, it must be specially provided that the rivet die is not removed from the rivet head until the rivet has cooled sufficiently. According to the researches of Bach it appears that the shearing of the rivets and the destruction of the whole riveted seam does not generally take place until the plates have begun to slip. Therefore, the higher the resistance to sliding of the

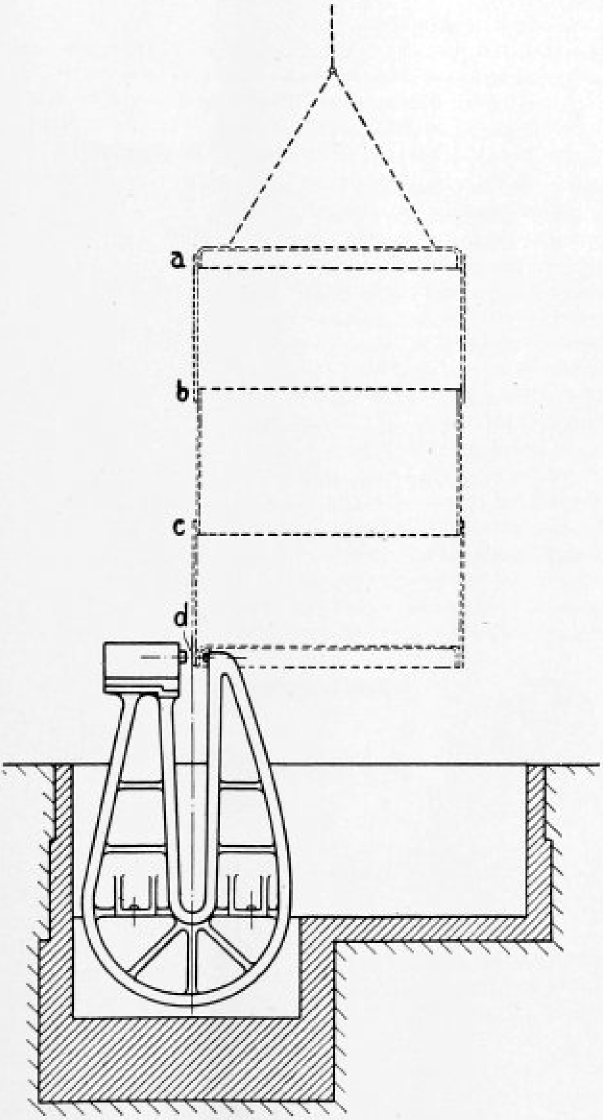


FIG. 12.

plates in a joint the stronger the joint will be. With machine riveting, according to the researches of Bach, this friction resistance is greater the longer the dies of the riveting machine are held on the rivet. If the rivet is still hot when the dies are removed, the shank of the rivet can stretch easily, and therefore the frictional resistance of the joint is proportionally lessened. If the dies of the riveting machine are removed from the rivet head too soon the frictional resistance will be no greater than with hand riveting. The results of this research should be carefully considered in marine-boiler construction, especially since holding the pressure on the rivet head for a longer time does not entail a loss of hydraulic pressure, but only a comparatively small expense in time and wages; yet one often sees in boiler shops the dies removed from rivet heads which are still red hot. A seam with high frictional resistance will naturally be tighter and, therefore, can be calked much more quickly and easily.

In both hand and machine riveting the rivets which are used have one head formed on a special machine, so that when the rivets are placed in position it is necessary to form only the second head. Occasionally machines are found for a process known as tack or pin riveting. In this process a round bar of iron or steel, after it has been heated to a red heat, is placed in the rivet hole and centered there, so that an equal

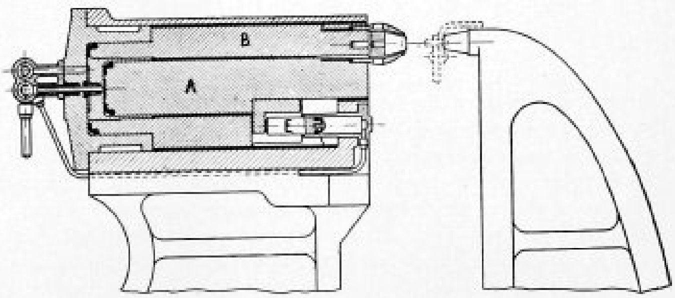


FIG. 13.

length of the bar protrudes on either side. Then pressure is applied on both the ends of the bar, so that both heads of the rivet are formed simultaneously. The chief objection to this kind of riveting is the difficulty of forming both heads of equal size. If the bar should not be heated uniformly one end will be upset before the other, so that the bar will be moved

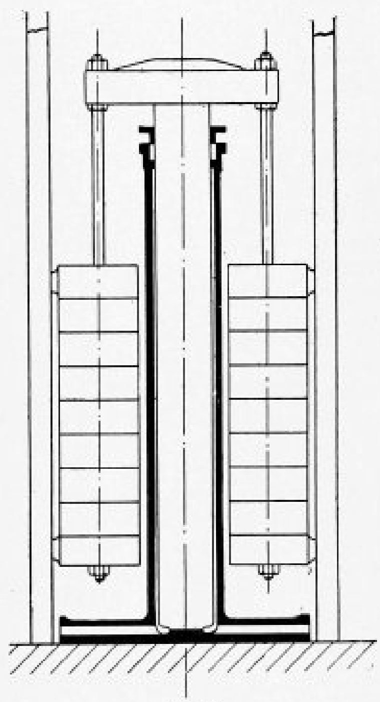


FIG. 14.

out of place in the hole and the heads will differ in size. Also, there is greater possibility that in this process a head will be found which will be eccentric with the shank of the rivet.

Hydraulic riveting machines differ essentially from pneumatic riveters. The latter work under a pressure of from 88 to 120 pounds per square inch, and need, therefore, in order not to use too large a plunger, some form of lever motion in order to produce the required pressure on the rivets. Since they are not as reliable as hydraulic machines they are seldom found except for the smaller sized rivets.

The usual method of riveting is as follows: The rivet, which has been heated in a rivet-heating furnace, is grasped in a pair of tongs and given a sharp blow in order to free it from scale. Then it is placed in the rivet hole from the inside, and riveted over by means of the pressure on the plunger in the hydraulic machine. Fig. 12 shows the outline of such a machine. It consists of two arms between which the boiler can be moved to any desired position by means of a crane. First the girth seam, marked *a*, is brought between the rivet dies; then the girth seam *b*, then *c*, and finally the seam *d* is

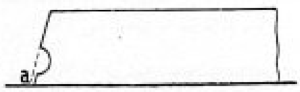


FIG. 15.

riveted up, provided the head, as shown in the illustration, is placed in the boiler with the flange turned out. Should, however, the flange be turned inside the boiler the last girth seam must be riveted by hand, since the right-hand arm of the riveting machine, which holds the stationary die, cannot reach the inside of the boiler. If the last girth seam is riveted by hand, rivets with countersunk heads are frequently used, since experience has shown that these press the plates together more tightly, and so compensate in some degree for the disadvantage of hand riveting as compared with machine riveting.

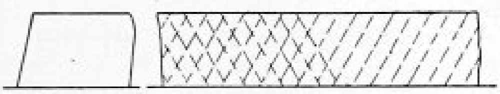


FIG. 16.

The American navy prescribes the application of countersunk rivets in all hand riveting. Moreover, countersunk rivets are frequently found in the combustion chambers and in places on the front ends of boilers where the smoke flues are connected.

The riveting machine is installed in a walled pit, partly in order to diminish the height of the shop and partly in order to bring the head of the machine in such a place that the riveting can be carried on at a convenient height relative to the floor of the shop. Fig. 13 shows the head of a riveting

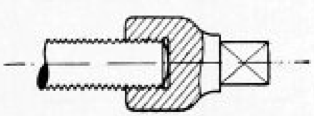


FIG. 17.

machine built by Haniel & Lueg. The plunger *A* is fitted on the right-hand end with a plate-closing device; that is, a ring which lies around the rivet hole and by means of which the plates can be pressed together. The plunger *A* is placed inside a second plunger *B*, which is fitted on the right-hand end with the movable rivet die which forms the heads of the rivets. The left-hand end of the head, as shown, carries the valves *C* and *D*, which control the flow of water under pressure to the plungers *A* and *B*. The hydraulic pressure is obtained by means of a pump and an accumulator, which serves also as storage place for the water under pressure. Fig. 14 shows an accumulator with a fixed cylinder, in which the piston, loaded with weights, is raised by means of the water which is pumped into the accumulator. When the piston reaches the highest point of its stroke the pump automatically stops. The loading of the piston for various pressures can be changed by taking off or by putting on weights. There are also accumulators in which the piston is fixed and the cylinder moves up and down. In these the great weight of the cylinder itself can be used to advantage in controlling the pressure.

For this type of accumulator it is difficult to arrange a satisfactory packing for the lower stuffing-box. Occasionally a carbonic acid accumulator is found. The usual working pressure with hydraulic riveting apparatus is about 1,500 pounds per square inch. One advantage of the accumulator

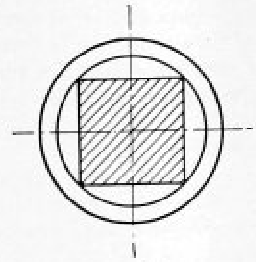


FIG. 18.

lies in the fact that near the end of each period when water is being withdrawn from the accumulator, and also after the pressure has been applied to form each rivet head, the pressure of the water, due to the force of the sudden fall of the heavy parts of the accumulator, is considerably increased.

Ordinarily the operation of the riveting machine is as follows: After a hot rivet has been placed in the plates which are to be riveted, the boiler is swung around so that the head of the rivet lies in the right-hand die, as shown dotted in Fig. 13. By opening the valve *C* the water is allowed to flow from the accumulator into the space behind the plunger *A*, so that this plunger, together with the plate-closing device, which is fastened to it, is driven towards the right, pressing the plates against the stationary die. Then the valve *D* is opened, allowing the water to enter the space between the plunger *B*. Since the plunger *B* surrounds the plunger *A*, which is already under pressure of the water, it, together with the movable rivet die, which is fastened to it, will be driven

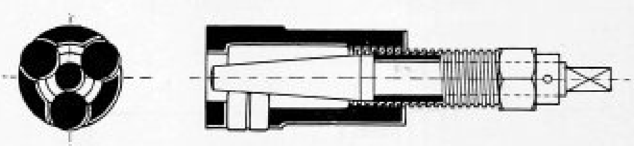


FIG. 19.

towards the right, under a pressure varying according to the difference in the area of the circular surfaces *A* and *B*. Thus, while the plates are forced together by the plunger *A*, the head of the rivet is formed by plunger *B*. If it is desired to use a greater pressure in forming the rivet, close the valve *C*. This will cause the hydraulic pressure to act on the whole area of plunger *B*, and therefore cause a still greater pressure on the rivet. For thin plates and small rivets it is not necessary to use the plate-closing device. In this case the plate-closing device is removed from plunger *A* and a rivet die substituted. The riveting is then done wholly with the small plunger *A* without the use of the plunger *B*.

In general, even for heavy work, it will not be necessary to use the plate-closing device on each rivet. In fact, this would be impossible where there are many rows of rivets, since there would not be room enough for the plate-closing device between the heads of the adjacent rivets. If the plate-closing device is used on every fourth or fifth rivet, the rivets lying between these can be driven without its use.

An automatic return stroke is provided for both plungers, so that the small piston *E* is placed under pressure while the valves *C* and *D* are closed. This causes the plungers *A* and *B* to move towards the left. In order not to waste the hydraulic pressure, the length of the stroke of the plungers is regulated according to the length of the rivets. The movable rivet die and the plate-closing device are placed eccentrically relative to the adjacent plunger, so that corner rivets or rivets in irregular places can be driven. For riveting the furnaces to the front head a portable hydraulic riveting machine is frequently used, which is built on the same principle as the stationary riveter, but which, naturally, is much simpler.

Calking the riveted seams can be done either in the English or German way. In the English way, as shown in Fig. 15, a recess is first calked in the edge of the plate with a round nose tool, seldom with a square tool, so that the upper plate is forced down tightly on the lower plate. Then with a lighter tool the surface marked *a* is calked. The German method of calking is as follows:

First, as shown in Fig. 16, the edge of the plate is calked in a fluted manner obliquely, first in one direction and then in the other, over its whole thickness. Then with a thick tool, which has a width of about two-thirds the width of the plate, the lower edge of the plate is calked, and finally with a second and third tool, which has a width of only one-half the former, or about one-quarter the width of the plate, the lower edge of the plate is tightly calked. Pneumatic tools can be used to advantage for calking. All seams, as well as the rivet heads, are calked both inside and outside.

For screwing in the stay-bolts and braces, a chuck, similar to the one shown in Fig. 17, is used, otherwise each stay-bolt must have a square head, which must be cut off after the bolt is screwed into place.

The screwing in of the stay-tubes is accomplished by means of a square taper pin, see Fig. 18, which does no damage to the tube. The plain and stay-tubes are expanded into both tube sheets, a roller expander, also called a mandrel, see Fig. 19, being used for this purpose. This consists of a tapered pin around which three small rollers are placed in a frame. These expanders will only enter the tube the proper distance, and the pin is provided with a square head and thread, so that when it is turned it forces the rolls against the tube and expands the walls of the tube against the tube sheet.

Repairs to Marine Boilers.

REPAIRS DUE TO DAMAGE.

The furnaces and combustion chambers of boilers suffer generally through overheating, caused principally through the presence of scale, the lavish use of oil, or shortness of water. The crown or upper part of the furnace comes down and in some cases has been found resting on the fire-bars. With corrugated furnaces, in such cases, the corrugations have disappeared. Where the furnace is down, and the difference between the horizontal and vertical diameters of the furnace is, say, 3 inches or over, the furnace should be renewed. In plain furnaces, it is sometimes possible to cut them below the line of fire-bars and renew the crowns only, but with the high pressures now used it is safer to renew them. With furnaces down less than 3 inches, the usual practice is to jack them up, when the furnaces are cold, molds suited to the particular type of furnace being interposed at the jack ends. Great care, however, is necessary subsequently, as such furnaces have a tendency to again come down. Cracks or slight fractures in furnaces and combustion chambers, in the part exposed to the fire, when not extending more than 2 or 3 inches, are fitted with small iron-screwed pins interlacing with one another. In combustion chambers, the damage usually shows in buckling between the stays, and when this is excessive, the plates require to be renewed, often difficult to do on account of the size and position of the plates; in a single-ended boiler it might mean removing one of the back end plates to effect repairs. Otherwise, in both single or double-ended boilers, the plates are renewed in sizes that can be passed through the furnaces. In less severe buckling, additional stays may be fitted between the other stays, special washers being made to suit the buckled part and the face of the nuts, when nuts are fitted. If the buckling extends over a large area of the plate it is better to renew it, or renew its worst part, in the manner previously referred to.

Tube plates are not often found very much damaged; but if it is necessary to renew one, the top front end plate would require to be removed. Where tube plates are seriously damaged it is generally found that the combustion chambers, furnaces, tubes, and, in some cases, the front and back end plates are also injured, and in such a case the boiler is probably ready for the scrap heap.

The boiler non-conducting covering, when injured by water, can be easily renewed, either wholly or partly, so also the lagging plates and bands.

REPAIRS DUE TO WEAR AND TEAR.

The boiler, as the source of power, is like the heart in the human machine, and requires the greatest attention. Where feed heaters, feed filters, evaporators, hydrokineters or other means of circulation, and natural draft, are fitted, one would think that few, if any, repairs are required to the boiler. An important factor, however, is the care taken in using it; besides, all vessels are not fitted with these auxiliaries, and corrosion and other defects in the boiler are consequently found.

The introduction of sea-water into the boiler, whether by means of leaking condenser tubes, or by using the auxiliary feed—when no evaporator is fitted—tends to the formation of scale on the different surfaces of the interior of the boiler. When scale forms on the furnaces, tubes, tube plates and combustion chambers, it interferes with the efficiency of the boiler, and, if allowed to become of sufficient thickness on the furnace crowns and other parts exposed to the direct heat of the fuel, leads to damage. Where it is necessary to use sea-water as feed, the water in the boiler should not be allowed to become too dense, and the boiler ought to be opened on every possible occasion and the scale removed. Special scaling tools are used for this purpose, except in the case of the tubes, which are difficult to scale.

To remove scale from the tubes when the deposit has grown to a considerable thickness, the following plan has been tried with success. Iron bars about 2½ inches diameter and from 2 to 2½ feet in length, having an eye at one end, to engage with a hook on a rod with a handle at the other end, made of sufficient length to place the bars in position in the tubes and to withdraw them as required, are heated to redness in, say, the donkey boiler furnace. Two of the heated bars are inserted in each tube that is to be scaled. A very short time suffices to heat the tube, which, on expanding, causes the scale to crack off. The bars are then withdrawn, and, if hot enough, inserted in another tube. The back ends of the tubes require to be examined when the boiler is again filled with water, as probably several of them may require re-expanding.

Pitting also takes place in some boilers, principally on the furnaces along the line of fire-bars and also on various parts of the combustion chambers. Several methods are used to prevent or stop this action—such as zinc plates, or electrogens, while soda, zinkara and other boiler fluids are also advocated for the same purpose. The zinc plates are more generally used, and, when judiciously and effectively fitted, give good results. If the pitting becomes deep along the sides of the furnace, and is not continuous, the pit holes can be drilled and rivets fitted.

* Abstract of paper presented before the British Institute of Marine Engineers, February, 1908, by M. Robert Elliott, B. Sc.

Often the water-space stays are found wasted at the necks and the portion of the combustion chamber around the necks grooved out and wasted. In such cases the stays require to be renewed, and it has been found that a nut, fitted close on the water side of the combustion chamber, as well as one on the fire side, has no evil effects to speak of, while it compensates for the reduction in strength of the combustion chamber plate around the neck of the stay. The bottom of the combustion chamber and the lower part of the back of the chamber waste more rapidly than the other parts of the chamber, and when these require renewal, the size of the furnace rules the dimensions of a plate it will let through, as the part to be renewed may have to be dealt with in two pieces.

When small patches to the combustion chamber require to be fitted, it is necessary to cut out the defective portion and advisable to fit the patch on the fire side, so that, if the holes in the patch split through to the edge by the action of the heat, such can be removed and a new patch of similar dimensions fitted. If the patch be fitted on the water side and the holes in the plate split through to the edge, it would be necessary to cut out a larger proportion of the plate and increase the size of the patch.

In fitting a patch in such a place as the bottom of the combustion chamber, adjoining the end of the furnace tube, the end of the furnace tube should be thinned down in way of the patch, and the patch fitted over the end, the rivets removed in the end of the furnace being renewed to cover and secure the patch. This insures that the patch can be calked all around its edges, which would not be the case if the patch was butted up against the end of the furnace tube. The patch may be joggled over a seam, in a repair such as this, but it is not so satisfactory for fitting, riveting, or calking.

To save the mouths of the furnaces from the wear of the firing tools, and in corrugated furnaces to easily withdraw the ashes, loose thin plates are usually fitted in the bottom of the furnaces.

If the lower part of the mouth of the furnace is wasted, and the front end plate is flanged outwards to take the furnace, a shoe-piece in the form of a U may be fitted over the wasted part. A similar patch could be fitted at the bottom of the front circumferential seam, where the front end plate is flanged outwards to take the bottom shell plate if it be found wasted.

The rivets and seams, at the lower part of the circumferential seams of the shell plates, are often found leaking (generally caused by the sharp difference in temperature in raising steam too quickly). When leaking slightly, the rivets and seams may be re-calked and the seams inside covered with either Portland or a patent cement. If the rivets and seams are seriously leaking and the shell plates wasted, the rivets should be renewed, and a thin covering plate fitted over the rivet heads and wasted plates, and bedded in red-lead putty or other jointing material.

To prevent the front end plate becoming wasted by the water used for cooling the ashes, a thin covering plate, or other means of protecting it, should be fitted. The nuts of stays in the combustion chamber, where the flame strikes them, are often found burnt or split in their weld; and in this case the nuts may be removed, the end of the stay re-screwed with a die, and the nuts renewed to suit. When the end of the stay is too small to have an efficient nut fitted, the stay requires to be renewed, generally of larger diameter.

Boiler chocks, when fitted at the fore and after ends of a boiler to prevent its movement, are often found wasted, owing to the water used for the ashes. It is better to fit a cast-iron chock at the bottom of the boiler, with angle-iron stoppers on both sides in a fore and aft line riveted to the shell plates.

Special attention should be given to the proper fit of manhole doors, and the doors renewed, either wholly or partly, if found defective.

The introduction of oil into a boiler is a more serious matter than that of sea-water, and as little oil as possible should be used for cylinders or piston rods, a feed filter being fitted if necessary. The oil when deposited on the furnace crowns or other parts subjected to the direct action of the heat, causes serious damage. On account of the amount of oil generally used during the trial trip or trips of a steamer, it is advisable to have the boilers emptied and thoroughly cleared of any oil deposits and refilled with fresh, clean water before proceeding to sea, and the condenser boiled out with caustic soda—the latter is important, as it takes some time before the most of the oil finds its way into the boiler or boilers.

The introduction of air into a boiler through the feed-pump causes corrosion, and in order to minimize this evil, slow acting automatic feed-pumps are usually fitted, and during recent years the conditions under which boilers are worked with the various appliances which have been introduced, and improvements made and the use of fresh water carried in a section of the ballast tank have, to a very large extent, eliminated the causes which shortened the life of the boiler.

How to Apply a Patch on a High-Pressure Boiler for Good Results.

BY G. W. SMITH.

There have been several articles written on this subject from time to time, but the subject has not been made clear enough for an apprentice to grasp the idea as he should. There are seven operations to be performed in applying a patch:

1. Find out how much of the old sheet is to be cut to get a good bearing for the patch.

2. Mark off the patch 3½ inches larger in both length and width than the piece which is to be cut away. On the patch, 15/16 inch from the edge, mark a line for the rivet, or patch-bolt-holes. These holes should be spaced not nearer than 1⅞ inches or over 2 inches from center to center of holes. For patch bolts, drill the holes in the patch 21/32 inch, then put the patch in position on the boiler and mark off four holes, one in each corner of the patch. Drill these holes in the boiler, tap them out with a ¾-inch tap and screw the bolts in; this serves to hold the patch in place while drilling the balance of the holes, and insures good, fair holes.

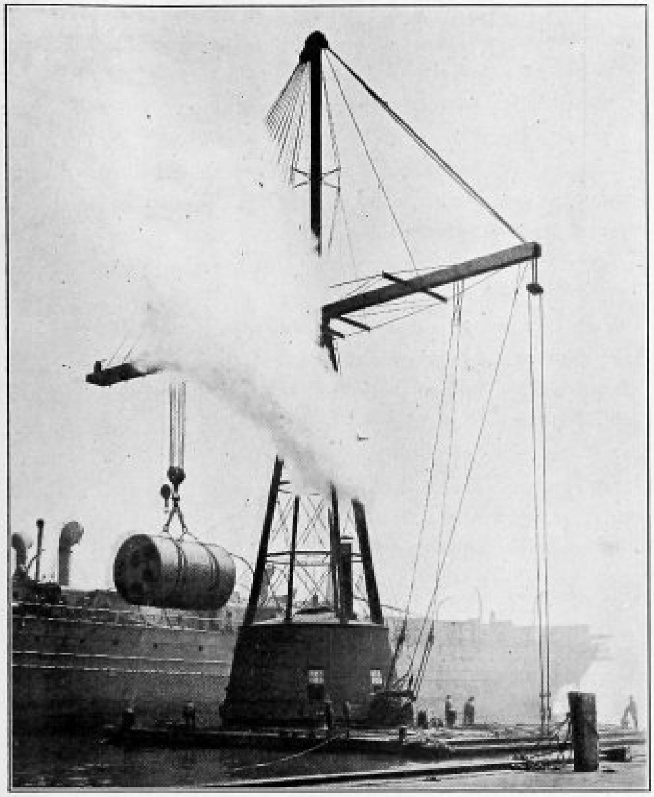
3. Take the patch off and ream all the patch-bolt holes in the patch out to 25/32 inch, and countersink them to suit the bolt heads. The bolts should be nicked low enough on the head to give them the appearance of a countersunk rivet after being worked up.

4. Remove all burrs from the patch and put it in place. Screw in all the patch bolts tightly, and with a hand flatter work carefully around all the bolts, after which tighten up on the bolts again.

5. Starting at the top of the patch with a fuller, work up the first bolt carefully and tighten up on it, also do the same to the ones on each side of it. This serves to keep the patch up to the sheet in good shape and makes a tight job. Work the rest of the bolts in the same manner.

6. Starting at the top, again tighten up on the bolts until the heads are twisted off, and then with a round-nose tool cut the edge of the bolts well into the edge of the countersink in the patch. This is done in order to keep the fire from pulling the heads of the bolts away from the sheet more than for anything else.

7. Chip and calk the patch, and you have a first-class job. The thickness of the patch should, of course, be proportioned to the thickness of the material in the boiler.



FLOATING CRANE AT BOSTON NAVY YARD.

Installing the Boilers of the U. S. S. Yankee.

The United States ship *Yankee,* which is now being completed at the Boston navy yard, was launched previous to the installation of the boilers in the ship. Hitherto there has been no means at this yard of transferring such heavy weights as boilers, etc., from the dock to a ship which is already afloat. On April 1, 1908, however, the floating derrick of 75 tons capacity, which has been in use in the navy yard at New York for a number of years, was transferred to the Boston yard for the purpose of installing the three double-ended Scotch boilers on board the *Yankee.* A description of these boilers was published in the March, 1908, issue of THE BOILER MAKER. They are each 13 feet 10 inches mean diameter by 20 feet 1¾ inches long outside the heads. Each boiler has six corrugated furnaces with separate combustion chambers and 504 3-inch tubes. The total heating surface in each boiler is 3,527 square feet, and the grate area is 138 square feet, making the ratio of heating surface to grate area 25.55 to 1. The total weight of each boiler stripped for installation was 139.575 pounds; this included the internal piping and fittings but no furnace fittings or other parts.

The derrick was brought alongside the sea wall when the boilers were in readiness for installation. The method of making the transfer was as follows: The boiler was lifted from the sea wall by the derrick, which was then floated to the side of the vessel and made fast. The carriage on the arm of the derrick was then racked out to bring the boiler over the center of the boiler hatch, and the boiler lowered into place. The total time consumed in installing each boiler from the time of lifting from the dock to lowering in the ship was two and one-half hours.

This derrick fills a long-felt want at the Boston navy yard, and has already demonstrated its value, and the good judgment of the Navy Department in assigning it permanently to this station. JOHN E. TRUCKSES.

Locomotive Construction in 1907.

According to the figures given in *The Railroad Gazette* there are twelve locomotive builders in the United States and Canada, and during the year 1907 these concerns built 7,362 locomotives, of which 6,564 were for domestic use and 798 for export. This is an increase of 6 percent in the total output over the preceding year. The export output increased to 11 percent as against 5 percent for the domestic output. The Canadian output of locomotives was 264, or about 3.6 percent of the total. These figures do not include locomotives built in railroad shops or old locomotives which were rebuilt or repaired. There were 330 electric locomotives and 240 compound locomotives built as against 237 and 292, respectively, the preceding year. The following table shows the number of locomotives built during the last fifteen years:

Year.	No. Built.	Year.	No. Built.
1893	2,011	1891	3,384
1894	695	1902	4,070
1895	1,101	1903	5,152
1896	1,175	1904	3,441
1897	1,251	1905	*5,491
1898	1,875	1906	*6,952
1899	2,475	1907	*7,362
1900	3,153		

* Includes Canadian output.

Estimating the average cost for a locomotive at $16,000, the total cost was $117,792,000. This is a slight increase in cost over the preceding year, and the increase is due largely to increased average weight of modern locomotives. The total amount spent by railroads for new rolling stock shows an increase of about 25 percent over that for the year 1906.

A Bad Case of Corrosion Due to Electrolysis.

It is not always easy to trace out the exact cause of corrosion in a steam boiler. In the case cited below, however, there is only one conclusion which can be drawn and that is, that the corrosion was due to electrolysis. How destructive this corrosion was will readily be seen from the description of the condition of the interior of the boiler. In July, 1903, the United States collier *Brutus* arrived in Pago, Samoa, after a trip of over 15,000 miles around the Horn with a cargo of coal for a naval station on the Island of Tutuila. The vessel had considerable difficulty in making the voyage and was long overdue when she arrived.

An examination of the boilers upon her arrival showed that three of her corrugated furnaces had collapsed so badly that one boiler had to be cut out and the pressure reduced on the other. More than 200 tubes were split, not to mention other minor mishaps. The tubes, which were leaking, were perforated with numerous small holes, which had the appearance of having been drilled with a very small drill and slightly countersunk. The shells and combustion chambers of the boiler showed signs of excessive corrosion and pitting everywhere. The entire water space in each boiler was covered with from ⅛ inch to 2 inches of peculiar brown sediment, and it was found that the zinc slabs had entirely disappeared, although the baskets and hangers were still in place.

An examination of the brown sediment which was found in the water space of the boiler showed the reason for such excessive corrosion. This sediment was nothing less than the copper paint with which the double bottom compartments carrying fresh water for the boiler feed had been painted. In some way this paint had been scaled off the tanks and carried into the boiler with the feed water. The presence of so much copper set up a very great electrolytic action inside the boilers so that the zinc plates collapsed, after which the corrosion naturally attacked the tubes and all exposed metal.

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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.

The edition of this issue of The Boiler Maker comprises 7,000 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Boiler Flues—Explosions.

Two subjects were very thoroughly discussed at the recent convention of Master Boiler Makers—"Boiler Flues" and "Boiler Explosions." The former is of importance, since the maintenance of flues largely determines the mileage which can be obtained from a locomotive between shoppings; while the latter affects directly the safety of hundreds of lives and thousands of dollars' worth of property.

The method of applying flues is nearly universal throughout the country and it is considered that this work is done as well as it possibly can be. The important thing about the subject of boiler flues is, therefore, the determination of the cause of leaky flues, and the best methods of preventing leakage. The main cause for leaky flues is the great variation in temperature at the fire-box end, causing unequal expansion and contraction of the flues and the adjacent parts of the boiler. This variation in temperature is caused by many different things: cold air striking the lower part of the flue sheet and passing through the lower flues when the fire door is opened; difference in temperature between the feed water in the lower part of the boiler and the steam in the upper part, etc., but perhaps the most harmful condition and one which might be partly overcome is the use of bad water. Bad water causes heavy deposits in the boiler, which not only tend to cause overheating of tubes and plates, but mean frequent washing out of the boiler, an operation which, even under the best of conditions, is one of the greatest sources of flue trouble. The remedy for this cause is obviously the treatment of feed water, and better and more intelligent methods of handling the engine on the clinker pit and in the roundhouse.

The number of different ways of working flues at the roundhouse, which were described as being successful, bring out the fact that no hard-and-fast rule can be laid down for this work for all roads under all conditions. The use of the Prosser expander seems to be nearly universal, although one claim was put forward for the roller expander on the ground that time could be saved by its use. The amount to be allowed for a bead on a tube should depend upon the thickness or gage of the tube, varying from 1/8 inch for a 10-gage tube, to 3/16 inch, strong, for a 12-gage tube. The comparative merits of narrow and wide coppers seem to be debatable, but the practice of swedging the end of the flue from 2 inches down to 1⅞ inches seems to be wholly desirable, since it gives increased circulation, tends to stop flue leakage, and partly prevents the stopping up of flues.

As regards boiler explosions, facts seem to indicate that most of them are due to neglect, principally on the part of the man operating the boiler. The importance of thorough and careful inspection cannot be too strongly emphasized, especially in parts of a boiler which are not readily accessible, and which might be passed over by a careless inspector. Of the greater number of explosions or partial failures, the immediate cause is very apt to be low water. The old belief that it is dangerous to inject cold water into a boiler when the crown sheet has become overheated seems to be pretty well discredited, and the effect of cold water is now thought to merely lower the temperature of the boiler and not to cause a rapid evaporation of steam or any great damage to the plates. The best method of preventing accidents, due to low water, is to keep the gage cocks and water glass in perfect order, so that there will be no guesswork as to where the water stands in the boiler at all times. One of the greatest sources of failure in a boiler—the breakage of stay-bolts—has been partially overcome by a general use of flexible bolts, although some claim that stay-bolts are eaten off by corrosion, rather than broken by excessive strains. The hammer test for finding fractured bolts which are not broken clear through was shown to be unreliable.

An Acknowledgment.

We desire to express our appreciation of the action taken by the International Master Boiler Makers' Association in adopting the following resolution:

"Substantial evidence of the esteem in which our association and its work is held is afforded in the recognition accorded by the technical press. We tender them special thanks for the liberal space and attention given us. We believe it is no more than just to particularly refer to THE BOILER MAKER and its representatives, as they have done so much to assist in promoting the welfare of the organization."

Individually we have always found the members of this association among our most loyal supporters, therefore this indorsement of our work coming straight from the association itself is doubly gratifying.

Convention Notice.

As already announced, the twentieth annual convention of the American Boiler Manufacturers' Association of the United States and Canada, will be held July 14, 15 and 16, 1908, at Atlantic City, N. J., with headquarters at the Marlborough-Blenheim Hotel. At this convention many matters of importance are to come up for discussion, among them being the question of State laws governing the construction and quality of material used in boilers. Col. E. D. Meier has called attention to the fact that the laws recently adopted by the State of Massachusetts governing boiler construction and inspection, contain specifications for steel which permit a poorer quality of material than is allowed by the specifications of the American Boiler Manufacturers' Association. As these laws may become general in New England, it is certainly a matter of importance to the manufacturers to prevent anything of this sort from happening, as they have fought too long and worked too hard for better materials, better construction and better conditions to permit anything that is now inferior to creep in and take its place. It is earnestly hoped that there will be a large attendance at the convention, since many who have been kept away the last few years on account of an excessive amount of business should, under the present conditions prevailing throughout the country, find sufficient time to attend.

TECHNICAL PUBLICATION.

Autogenous Welding of Metals. By L. L. Bernier, M. E. Size, 4½ by 6½ inches. Pages, 45; illustrations, 32. THE BOILER MAKER, New York, 1908. Price, $1.00.

This work gives a detailed description of the various means employed for obtaining high temperatures for the welding of metals. The most common forms of apparatus are thoroughly described, and an account is given of how this process has been applied commercially. The book is divided into three chapters. The first chapter gives a detailed comparison both as to cost, suitability for various kinds of work and ease of handling of the various types of blow-pipe burners in use. The three important burners described are the oxyhydric burner, using oxygen and hydrogen; the oxyacetylene burner, using oxygen and acetylene, and the oxygas burner, using oxygen and illuminating gas. Comparison is made in the case of portable welding apparatus between blow-pipes using dissolved acetylene and oxygen and hydrogen, and, in the case of stationary welding apparatus, between oxyacetylene blow-pipes, using acetylene supplied by a generator and the oxygas blow-pipe. In both cases the subject is thoroughly discussed from the point of view of the comparative cost prices of the two systems and from the point of view of easiness in handling and application. Charts are given on which curves have been plotted showing the total cost per unit distance to weld various thicknesses of metal by each of these systems. The curves show the total cost, including gas and workmanship, and also the cost in gas alone.

In the second chapter a detailed description is given of different types of oxyacetylene welding plants. These plants are divided into two classes, those which use both the oxygen and acetylene under pressure and those in which one of the gases is obtained under only a very slight pressure, the other gas being under sufficient pressure to draw out the first and insure a proper velocity to the mixture at the mouth of the blow-pipe. Different types of blow-pipes are described as well as the regulating valves, safety valves, etc.

The remaining part of the book is taken up with a description of the method of using an oxyacetylene blow-pipe in welding different shapes, such as plates, bars, etc. Numerous line drawings are given, showing the exact manner in which such pieces should be prepared and fitted together to obtain the best results. A comparison is made between the cost of constructing a steam boiler with riveted joints and joints welded by means of the oxyacetylene apparatus. Since the greatest usefulness of this apparatus has so far consisted in its application to repair work numerous examples are given of various repair jobs on which it has been used to advantage.

COMMUNICATIONS.

An Old Time Punch.

EDITOR THE BOILER MAKER:

In the May issue of THE BOILER MAKER an article was published, describing some early boiler makers' machine tools. The article put me in mind of an old-fashioned punch that I saw in use as late as 1889. It was similar in shape to the alligator shear, the lever being operated by a connecting rod attached to a crank on the shafting. The lever was raised and lowered with every turn of the shaft, but there was so much lost motion between the knuckle joint and the plunger that the punch would do no work unless a wedge-shaped piece of iron, with a handle at one end, was shoved into the joint to take up the lost motion. Thus, although the punch was running continuously, a working stroke was made only when the iron wedge was inserted in the joint.

The manner of doing the work in this shop at that time, accorded well with the style of the punch. Some small, horizontal tubular boilers were under construction; the shells were rolled up without any rivet holes for the front head; the back head was put in and the rivet holes in the flange were marked with white lead. The flange was then punched on the old-fashioned punch, after which the tube holes were drilled; the back head was then placed on top of the front head, the tube holes of which were drilled, both flanges being down; the tube holes were sighted to bring them in line; also the rivet holes, or rather the place for the rivet holes in the front head, were sighted from the holes in the back head; the holes were then marked with a white-lead stick (not gaged), and afterwards punched. The back head was then placed in the shell and the tube holes were leveled up; the front head was also put in and the tube holes leveled. The distance between the tube sheets was then gaged by placing a few tubes through the head. The holes for the flange were then marked on the shell by a white-lead stick and afterwards punched on the old-fashioned punch. The work was done quickly and fairly well. "OLD-TIME BOILER MAKER."

EDITOR'S NOTE.—The type of old-fashioned punch described by "Old-Time Boiler Maker" is in use to-day in some of the most modern boiler shops in the Middle West. These machines apparently give good satisfaction, and, for work within their capacity, the men who operate them say they give excellent results.

Round-House Flue Work.

EDITOR THE BOILER MAKER:

Locomotives have been built of such enormous sizes in the last few years, especially as regards the length of the shell, or barrel, as it is sometimes called, that it is necessary to use tubes varying in length from 16 to 20 feet. As these long tubes are not of any heavier gage or thickness than the tubes used in the past, I believe this is a point which has a good deal to do with the leaking of flues. Engines come from the shops and are not in service over three weeks, and sometimes not as long as that, before they commence to give trouble with leaky flues. This happens just as frequently in the shops which are best equipped with all the latest pneumatic tools and plenty of air pressure, and, above all, with as good a set of boiler makers as there are anywhere in the country in a railroad shop.

From my experience, I know the round-house boiler maker is ready at any moment to call the back-shop man anything but a Sunday-school name, and say he did not know how to put in a set of flues, or did not care whether he put them in right or not. (As the poor fellow in the round-house would have to worry with them for the next eight or ten months, this is exactly what the shop man thinks to himself.)

I have had as many as ten engines dead in the house waiting for me on my arrival on a Sunday morning; of course this includes two local and two work-train engines; these four to have the stay-bolts examined and the soft plugs renewed. The stay-bolts were examined under an air pressure of from 60 to 90 pounds per square inch, and the hose was coupled and uncoupled by myself, as the master mechanic did not think there was work enough to let us have a helper on Sundays or on a holiday. This being the case, most men will pitch in and get through with the job as quickly as possible, saying to themselves, "I'll fix her up better the next time she comes in leaking," which will be on her next trip.

The foreman came to me one day and made me acquainted with an engineer. His engine was continually giving considerable trouble with leaky flues. He told me if I fixed her up so he could make four round trips without having to knock out the fire he would present me with a box of good cigars. He said he was tired of making out the same report every trip, and especially at each end of the division. I went into the fire-box and gave the flues a good examination. They were 2-inch flues swedged to 1⅞ inches on the fire-box end, but had been rolled so much that a 2¼-inch rolling tool would not tighten them in the flue sheet. The beads on about 200 out of the set of 378 were in a very bad condition, and several of them were completely gone, and the flues had started pulling in the holes, some of them having gone ⅛ inch beyond the edge of the sheet.

I got some new 2-inch tubing and had fifty or sixty thimbles cut 1⅛ inches long; cleaned the dirt out of the ends of the tubes, and put the thimbles in the ends, leaving enough for a bead (3/16 inch) projecting out beyond the sheet. Then I rolled them good and calked the thimble, making a new bead that could not be told from the original bead. With an air hammer I calked all the old beads down to the sheet solid, and made a very good job. The engine made five round trips before it leaked again, but even then it did not leak badly enough to have to give up its train on the road, as had been the custom before this operation.

I have heard both old and young boiler makers talk on the merits of the prosser tool, but I would debar its use on old work if I were in authority. My opinion is that the prosser tool does more harm than good on old flues, for the simple reason that the flue being rolled in both sheets is held rigid, and when the pin is driven in the tool the metal will give too much at the end of the flue in the fire-box, where the most strength is required. I have seen flues cut so badly by the prosser expander that they would leak and have to be taken out of the boiler, while the boiler maker who used the tool said that he did not understand why it was he could not keep the flues tight, since he had had good results using this tool on new work.

Errata.

Through a regrettable error credit was not given to the *Locomotive Firemen and Enginemen's Magazine* for the article "Locomotive Boilers," by W. L. French, published on page 148 of our May issue.

In the description of a large punch, manufactured by Williams, White & Company, Moline, Ill., on page 162 of our May issue, the weight of the machine is given as 6,300 pounds. This figure should have been 63,000 pounds.

PERSONAL.

H. H. TOFTE, together with Messrs. Frank Wilberg & W. E. Nicholson, has incorporated the Tofte Boiler & Sheet Iron Works, Houston, Tex.

T. A. JAMESON, formerly foreman boiler maker of the Southern Railway shops at Knoxville, Tenn., has resigned and accepted a position as boiler inspector with the Travelers Indemnity Company, of Hartford, Conn. His address is now care of J. E. Lutz, Knoxville, Tenn.

J. J. MCGRATH, 1500 North Broadway, St. Louis, Mo., formerly of Pittsburg, Pa., has recently started in the boiler and sheet iron business, taking up a general line of boiler, sheet metal and erecting work.

A. ANDERSON, formerly of Mexico City, has taken the position of foreman boiler maker at the shops of the Mexican National Railway at San Luis Potosi, Mexico.

J. F. MURPHY, who for many years has been mechanical engineer, and lately superintendent of the Cooke works of the American Locomotive Company, has severed his connection with that concern, and will open an office in room 1824 in the Hudson Terminal buildings, 30 Church street, New York, as consulting engineer.

F. B. SLOCOMB, formerly one of the New York representatives of Joseph T. Ryerson & Son, Chicago, has recently severed his connection with that concern, and is now allied with the Continental Iron Works, West and Calyer streets, Brooklyn, N. Y.

J. J. MADDEN has recently been promoted to foreman boiler maker of the Rock Island Company, at Fairburg, Neb.

H. M. BARR, recently connected with the Davenport Locomotive Works, Davenport, Iowa, is now foreman boiler maker with the Chicago, Burlington & Quincy Railroad, at Lincoln, Neb.

S. A. MCMONAGLE, layer out at the Missouri Pacific shops at Sedalia, Mo., was promoted on May 20 to foreman boiler maker with the same road at Alliance, Neb.

W. O'BRIEN, general foreman for the Illinois Central, has been transferred from Chicago to McComb, Miss.

W. MCINTOSH has been appointed master mechanic with the Illinois Central at East St. Louis, Mo., vice H. Eich transferred to Memphis, Tenn.

C. STEEVES has been promoted from assistant foreman to general boiler inspector of the Intercolonial Railway at Moncton, N. B.

Boiler corrosion is due to other causes than mere hardness of the water. The present methods of water purification usually leave a residue of sulphate of soda in the water, which becomes more and more concentrated as time goes on, and is found to attack the boiler to a considerable extent. Nitrates and chlorides, which are also found in the water, are even more corrosive than the sulphates, and worst of all is chloride of magnesia. It is, therefore, necessary to keep the concentration down below the point where these salts will attack iron or steel. As the water in the boiler will not be uniformly mixed the concentration is apt to be a maximum where the evaporation is greatest or at a point of greatest heat in the boiler, and these points are likely to be the first attacked. It has been recommended that a boiler be emptied once a week and thoroughly washed every two months in order to avoid the accumulation of these soluble salts.—*Iron Age.*

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—1. What should be the capacity of a safety valve?
Q.—2. What kind of material should be allowed in boiler tubes?
Q.—3. What kind of material should be allowed in boiler shells, and what is its chemical composition?
Q.—4. Explain how boiler heads are flanged. DOLLY BAR.

A.—1. The capacity of a safety valve should be such that when the valve is lifted by the steam pressure at which it is designed to operate, the effective opening shall be sufficient to discharge all the steam that can be generated by the boiler when working at its full capacity. If the valve has a flat seat the effective opening will be equal to the circumference of the seat multiplied by the lift of the valve. If the valve has a conical seat the effective opening will be the circumference of a line drawn at the middle of the valve seat multiplied by the lift of the valve measured at right angles to the seat. The lift in this case would be equal to the vertical lift of the valve multiplied by the sine of the angle of inclination of the seat.

The shortest rule which can be given for the capacity of a safety valve is that there shall be one-third of a square inch of effective opening for every square foot of grate area in the boiler. This rule is, however, too much a rule of thumb to be depended upon under all conditions. A better rule is to make the area of the effective opening equal to seventy times the weight of steam discharged per second divided by the absolute pressure on the boiler; that is, the pressure as read from the gage plus 14.7.

In the above formula the weight of steam discharged per second must be equal to the weight of steam which the boiler is capable of generating per second when urged to its full capacity. This may be found by multiplying the number of pounds of water evaporated per pound of coal by the number of pounds of coal burned per square foot of grate area per second and then multiplying the result by the number of square feet of grate area in the boiler.

For example, in a boiler operating at a pressure (by gage) of 150 pounds per square inch it may be assumed that 8 pounds of water are evaporated for every pound of coal consumed, and that 20 pounds of coal are burned per square foot of grate surface per hour. If the grate is 6 feet by 6 feet then the number of pounds of coal burned per hour will be $6 \times 6 \times 20 = 720$, and the weight of steam evaporated per hour will be $720 \times 8 = 5{,}760$ pounds. Therefore, the weight of steam evaporated per second will be $\frac{5{,}760}{60 \times 60} = 1.6$ pounds, and the area of the effective opening of the safety valve should be

$$\frac{70 \times 1.6}{150 + 14.7} = \frac{112}{164.7} = .68 \text{ square inch.}$$

The lift of a safety valve seldom exceeds 1/10 inch. Assuming that 1/10 inch is the lift in this case the circumference of the valve seat will be $\frac{.68}{.1} = 6.8$ inches, and the diameter should be $\frac{6.8}{3.1416}$, or about 2 3/16 inches.

2. For lap-welded boiler tubes either charcoal iron, wrought iron or mild steel made by any process may be used; for seamless cold-drawn steel tubes, mild steel made by the open-hearth process should be used. This steel will, of course, be a low carbon steel, and should not contain more than .04 percent phosphorus or sulphur. Its physical properties must be such that a test specimen, 3 inches long, can be flattened by hammering until the sides are brought parallel to the curve on the inside at the ends not greater than three times the thickness of the metal without showing cracks or flaws, and also a flange shall be turned all around the end of the tube to a width equal to 3/8 inch beyond the outside body of the tube. All tubes must stand expanding, flanging over on the tube plate and beading without showing a sign of weakness or defects. For information regarding the comparative merits of the various materials used for boiler tubes we would refer you to page 124 in the April, 1908, issue of THE BOILER MAKER.

3. Boiler shell plates should be of mild open-hearth steel of the following properties:

Its tensile strength should be from 55 000 to 65,000 pounds per square inch; the elastic limit not less than one-half the ultimate tensile strength; elongation in 8 inches, 28 percent; cold and quench bends, 180 degrees flat on itself without fracture on the outside of the bent portion; maximum phosphorus, .04 percent; maximum sulphur, .04 percent. It is not necessary to specify percent of carbon content in the steel, since this affects directly its physical properties—that is, the tensile strength and elongation; and as these are specifically limited, the amount of carbon in the steel must be such as to bring these properties within the range of the specifications.

4. Boiler heads are flanged in different ways according to their sizes. Small heads may be flanged in one operation by heating the plate all over and placing it in a hydraulic press between large dies of the proper size to flange the required head. The dies are forced together by hydraulic pressure, turning the flange down and leaving the head smooth. It is obvious that this operation cannot be performed on boiler heads several feet in diameter, nor on heads which are made in sections of two or more plates. Such heads are flanged by heating a small portion of the plate at a time and turning over the flange by means of a hydraulic sectional flanging machine. This machine has two vertical plungers and one horizontal plunger. The plate is held on the former, or die, by one of the vertical plungers, while the other is brought down upon the flange, turning it over the edge of the die. The horizontal plunger, fitted with a suitable shaped die, is then brought up against the part of the plate thus flanged over, smoothing it and giving it the desired shape. A plate flanged in this way must be afterwards carefully annealed.

Boiler heads are also flanged in a spinning machine. In this machine the circular plate is held between two revolving discs while the edge of the plate is turned down against a stationary vertical roller by a movable roller, the position of which can be changed by the operator.

Q.—If a boiler set athwarthships has 8 inches of water on the table, and the steamer takes a list of 15 degrees to starboard, what would the effect be on the depth of water on the table? MARINE.

A.—If the boiler is a single-ended boiler its length would probably be in the neighborhood of 11 feet. So the relation between the increase or decrease in the depth of the water at one end of the boiler, due to an inclination of 15 degrees, would be given by the following formula:

$X = \frac{L}{2} \times \text{sine } a$; where X = increase or decrease in the height of the water in inches; L = length of boiler in inches; a = angle of inclination. The sine of 15 degrees = .2588. One-half of 11 feet is 66 inches. Therefore, $X = 66 \times .2588$, or about 17 inches.

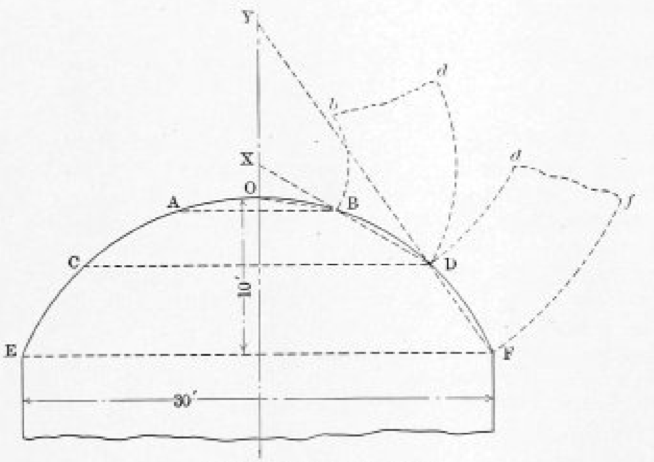
This formula gives only an approximation of the increase or decrease in the depth of the water at the end of the boiler, since it is based on the assumption that there is no increase or decrease in the depth of water at the center of the boiler when the ship is inclined. As a matter of fact, the point at which the depth neither increases nor decreases is probably a few inches either forward or aft of the center of the boiler, and the increase in depth at one end is not equal to the decrease at the other end. This is due to the fact that the area of the segment immediately above the normal water level is less than that immediately below, and also to the fact that the volume of water displaced by the combustion chamber at one end of the boiler differs from the volume of water displaced by the tubes at the other end.

Bearing in mind these limitations it will be seen that the decrease of 17 inches in the depth of the water figured above would bring the back of the combustion chamber nearly 9 inches out of water if it were at the port end of the boiler, and about 25 inches below the level of the water if it were at the starboard end of the boiler, when the ship is inclined at an angle of 15 degrees to starboard.

The position of the boiler in the ship, that is, whether it is on the center line or on the port or starboard side of the ship, makes no difference in the problem.

Q.—How do you lay out a spherical head for a tank 30 feet in diameter, the height of the head from the top of the tank being 10 feet? F. O.

A.—*EOF* in the diagram shows the outline of a hemispherical head 10 feet high for a tank 30 feet in diameter. Divide the head into any number of parallel sections, as shown by



LAYOUT OF SPHERICAL HEAD.

the lines *AB*, *CD* and *EF*. The section *AOB* should be of such size that an ordinary dished head may be used. The radius of the blank plate for this section before dishing should be approximately equal to the length of the line *OB*. Lay out the sections *ABDC* and *CDFE* as though they were the frustra of right circular cones. A portion of the pattern for each of these sections is shown dotted at the right of the figure. To get the radius in each case, draw the lines shown dotted through the extremities of the sections, producing the lines until they intersect the center line of the tank. Thus the radii to be used in striking the pattern for section *ABDC* would be *XB* and *XD*, and for the section *CDFE*, *YD* and *YF*. The length of the edge of each pattern should be the length of the circumference of the circle of which it is the development; that is, the line *Bb* should be continued until its length equals the length of the circumference corresponding to the diameter *AB*. Similarly, the dotted lines *Dd* should be continued until their length equals the length of the circumference of a circle of which *CD* is the diameter.

Patterns developed in this way can only be considered as approximate, since in order to make the head of the tank a smooth surface, the plates should be pressed out to form a true spherical surface, and in this case it would be necessary to make slight allowances for the stretch of the plates. This is a point, however, which can only be determined exactly from experience. Although only two sections besides the dished plate at the top of the head are shown in the diagram, in practice it would be necessary to use a greater number of sections, each section being divided into a number of plates. The greater the number of sections taken the more accurate the patterns will be and the surface will more nearly approach the true spherical shape.

Q.—How do you find the area of the segment of a circular boiler head which requires bracing? M.

A.—For an example, take the 72-inch circle shown in Fig. 1, and find the area of a segment 26 inches high. All the information which is given is the diameter of the circle, 72 inches, and the height of the segment, 26 inches.

The easiest way to find the area of the segment is to find the area of one-half of the circle, and from this subtract the rectangular area shown by the line *M-m-n-N*. First, find the area of the circle, which equals $\frac{3.1416 \times 72^2}{4} = 4{,}072$ square inches. One-half of this, or the area of the semi-circle = 2,036 square inches. The area of the rectangle *M-m-n-N* is equal

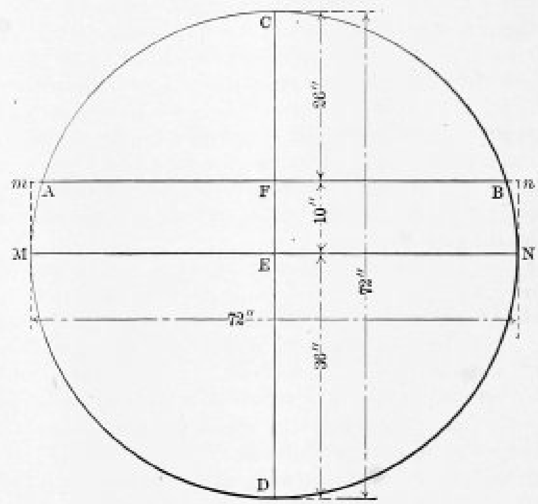


FIG. 1.

to the length 72 inches times the height, or the length of the line *E-F*. The length of the line *E-F* is equal to the radius of the circle, 36 inches, minus the height of the segment, 26 inches, or 10 inches. Therefore, the area of the rectangle = 72×10, or 720 square inches. Subtracting the area of this rectangle from the area of the semi-circle we have left, approximately, the area of the segment, $2{,}036 - 720 = 1{,}316$ square inches. This area is slightly smaller than the true area of the segment, the exact amount being twice the area of the small triangle *M-m-A*. This amount is, however, usually very small, and can be neglected.

If it were necessary to find the area of a 72-inch boiler head which must be braced, the diameter of the circle should be taken 6 inches less than 72 inches, since the flange of the head forms a sufficient support for a strip of the head 3 inches wide all around the edge. This would make the diameter of the circle 66 inches. Also the upper row of tubes will support a strip of the head 2 inches wide above the upper edge of the holes, so that, if the height of the upper row of tubes above the center of the boiler is given, the height of the segment can be found by adding 2 inches to this and subtracting the total from the radius of the circle 6 inches smaller than the diameter of the boiler. For example, in the head shown in Fig. 2, the diameter of the boiler is given as 72 inches. The center of the upper row of tubes is 7 inches above the center line of the boiler; the tubes are 4 inches in diameter. Therefore, the upper edge of the holes for the top row of tubes would be 7 + 2 or 9 inches above the center line of the boiler. Since the upper row of tubes is considered to brace a strip 2 inches wide above the holes, the base of the segment would be 9 + 2 or 11 inches above the center line of the boiler. The diameter of the circle will be 6 inches less than the diameter of the boiler, or 72 — 6 = 66 inches. The radius of the circle is, therefore, 33 inches, and the height of the segment will be equal to the radius minus 11 inches, or 22 inches. We have now the circle 66 inches in diameter, with a segment 22 inches high, from which data the problem can be worked out as explained in the case of the 72-inch circle in the first part of this article.

If it were desired to find the length of the segment, that is the length of the line *A-B* in Fig. 1, this can be found as follows:

One-half the length of *A-B* is a mean proportional between the distances *C-F* and *F-D*; that is, $AF^2 = CF \times FD$. From this relation you can get the length of *AF*, which, when multiplied by 2 will equal the length of the segment. The distance *C-F* was given as 26 inches. The distance *F-D* = the

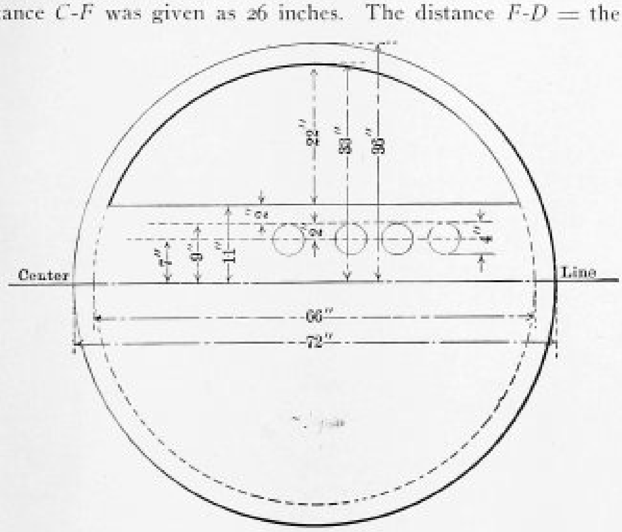


FIG. 2.

diameter of the circle, 72 inches, minus the height of the segment, 26 inches, or 46 inches. Therefore, $AF^2 = 26 \times 46$; $AF^2 = 1{,}196$; taking the square root of 1,196 we find $AF = 34.58$; multiplying 34.58 by 2 we find the length of the segment $AB = 69.16$ inches.

Having found the area of the segment, in order to find the number of braces required, multiply the area of the segment by the steam pressure and divide by the allowable pressure on a single brace. The result will be the number of braces. The allowable pressure on each brace will be equal to the sectional area of the brace at its smallest diameter, multiplied by the allowable stress per square inch of section which can be used for the grade of material of which it is made. This value runs from 6,000 pounds per square inch in short braces to 10,000 pounds per square inch in long braces.

Q.—Given a Scotch boiler 12 feet in diameter, built of double-riveted steel plates 1⅛ inches thick, of 65,000 pounds tensile strength; heads, ⅞ inch thick, stayed by 2½-inch wrought-iron stay-rods; pitched 15 inches center to center and fitted with double nuts; corrugated furnace ½ inch thick, mean diameter 36 inches; sides of combustion chamber ½ inch thick, stayed with 1-inch stay-bolts, pitched 6 inches center to center. What steam pressure would be allowed on this boiler?

SCOTCH.

A.—First determine the allowable working pressure on the shell of the boiler, and then see if the other parts of the boiler are sufficiently strong to withstand this pressure. As the boiler is of the Scotch marine type, and would probably come under the supervision of the United States Steamboat Inspection Service, it would be necessary to determine the allowable steam pressure according to the rules of this board.

To find the allowable working pressure on the shell, multiply one-sixth of the tensile strength by the thickness of the plate in inches and divide this by one-half the diameter of the boiler. This would give the allowable working pressure if the boiler were to be single riveted; but as the boiler is to be double riveted add 20 percent to this result, or multiply the result by 1.20. Therefore, allowable working pressure =

$$\frac{65{,}000 \times 1.125 \times 1.20}{6 \times 72} = 200 \text{ pounds per square inch.}$$

The shell of the boiler will be allowed a pressure of 200 pounds per square inch.

Next find out whether a corrugated furnace 36 inches in diameter, ½ inch thick, can withstand a pressure of 200 pounds per square inch. The pressure allowed on a corrugated furnace of the Morison type is found by multiplying a constant (found by experiment to be 15,600) by the thickness of the furnace in inches and dividing by the mean diameter.

$$\text{Allowable pressure} = \frac{15{,}600 \times .5}{36} = 216.5 \text{ pounds.}$$

The furnace can, therefore, safely withstand a pressure of 200 pounds per square inch.

Next, see if the heads, which are ⅞ inch thick and braced with 2½-inch wrought iron stays, pitched 15 inches center to center, can withstand a pressure of 200 pounds per square inch. The allowable pressure on a flat surface may be found by multiplying a constant (which for screwed stays fitted with double nuts without washers is 170) by the square of the thickness of the head expressed in sixteenths of an inch and dividing by the square of the pitch of the stays expressed in inches.

$$\text{Allowable pressure} = \frac{170 \times (14)^2}{(15)^2} = 148 \text{ pounds per square inch.}$$

The heads are, therefore, not capable of withstanding a pressure of 200 pounds per square inch, and, in order to make them as strong as the rest of the boiler, it would be necessary either to increase the thickness of the head or diminish the pitch of the stays. If ⅞-inch heads are used and the pitch of stays is reduced to 12¾ inches center to center, the heads will be capable of withstanding a pressure of 200 pounds per square inch.

The allowable pressure on the stays of the combustion chamber can be determined in the same way as the pressure on the heads. In this case, however, the plates are ½ inch or 8/16 inch thick, and the stays are 1 inch in diameter spaced 6 inches between centers. The stays are not provided with nuts, and, therefore, the constant to be used should be 120 instead of 170.

$$\text{Allowable working pressure} = \frac{120 \times (8)^2}{(6)^2} = 213 \text{ pounds}$$

per square inch. Therefore, the sides of the combustion chamber can withstand a pressure of 200 pounds per square inch.

The working pressure on the stay-bolts, assuming an allowable stress of 8,000 pounds per square inch of section, would be 175 pounds. If a stress of only 6,000 were allowed, the working pressure would be only 131 pounds. In either case either larger stay-bolts should be used or else the pitch should be reduced from 6 inches.

According to the dimensions given in this question, the boiler cannot be allowed more than 148 pounds per square inch working pressure, since it was found that this is the allowable working pressure on the heads. Since all other parts of the boiler can withstand 200 pounds per square inch, or over, it would be better to change the design of the heads either by making the heads thicker or reducing the pitch of the stays which brace the heads, so that a pressure of 200 pounds can be carried on this part of the boiler. Then the entire boiler will be strong enough to withstand a pressure of 200 pounds per square inch.

SELECTED BOILER PATENTS.

Compiled by
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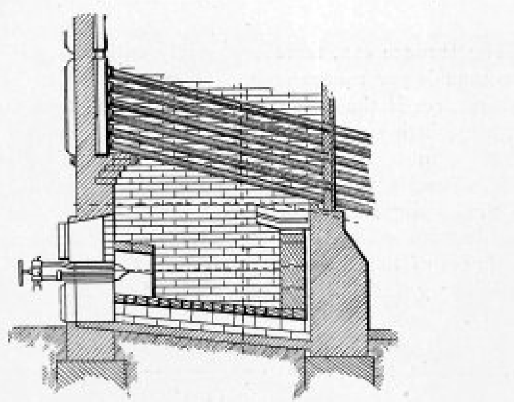
LOAN AND TRUST BUILDING,
Washington, D. C.

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

879,492. WATER-COOLED GRATE. William C. Richardson, Mystic, Conn.

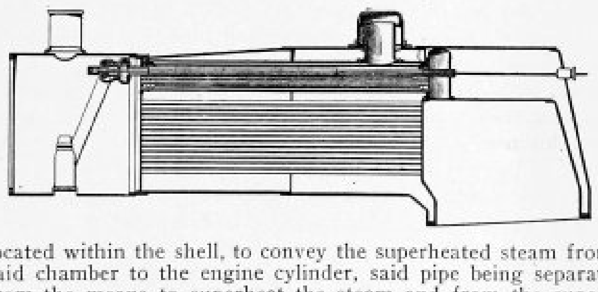
Claim.—A water-cooled grate for furnaces composed of a series of grate units, each provided with water spaces for the circulation of water therein; means for providing a circulation of water in said grate units; and means for cutting off the



circulation of water from any one or more of said grate units without affecting the circulation of water in the remaining grate units and for providing a water outlet in the water spaces of the grate units in which the water circulation is cut off. Seven claims.

880,562. SUPERHEATER. James M. McClellon, Everett, Mass.

Claim.—In a locomotive boiler, a shell having a smoke-chamber at one end and a fire-box at the other, a superheating chamber located entirely within the shell, means to admit the steam into the superheating chamber, means to superheat the steam while in the chamber, and a pipe, a portion of which is



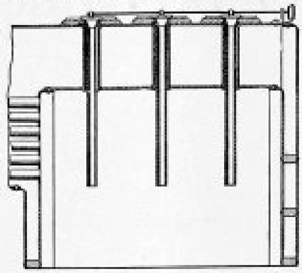
located within the shell, to convey the superheated steam from said chamber to the engine cylinder, said pipe being separate from the means to superheat the steam and from the superheating chamber, the portion of the pipe that is located within the shell being protected from contact with the water. Six claims.

879,682. MECHANICAL STOKER. Arthur R. Selden, Rochester, N. Y., assignor of one-half to C. Schuyler Davis, of Rochester.

Claim.—In a mechanical stoker the combination with a fuel supply of a longitudinally reciprocating projector, adapted to discharge fuel into the furnace; means for delivering fuel from said supply to said projector; means for gradually oscillating the delivery end of the projector from side to side by intermittent movements in each direction between the strokes of the projector; and means for actuating the projector. Twenty-five claims.

880,977. STEAM BOILER FURNACE. William Peter Darling, Meadville, Miss.

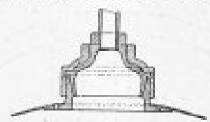
Claims.—The combination with the fire-box and the crown and top sheets of a boiler, of flues mounted in the crown and top sheets, brackets fastened to the top sheet over the outer



ends of the flues, air-feeding pipes mounted in said brackets and entering the fire-box through the flues, and means for excluding outside air from the flues. Four claims.

881,045. HANDHOLE PIPE-COUPLING ATTACHMENT FOR BOILER HEADS, ETC. Arthur C. Badger, Cohasset, Mass.

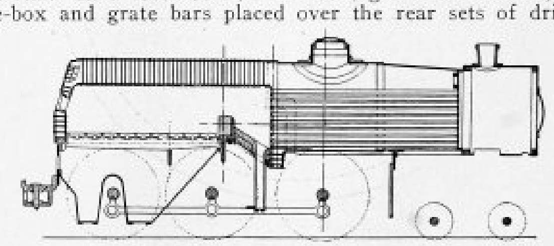
Claim.—An appliance of the character stated, comprising a handhole bushing having an external member adapted for at-



tachment to a receptacle head, a conduit section having one end enlarged, the said bushing and enlarged end having reciprocal bearing faces forming a tight joint, and means for detachably securing the section to the bushing. Three claims.

881,072. LOCOMOTIVE BOILER. Albert F. Helbling, Philadelphia, Pa.

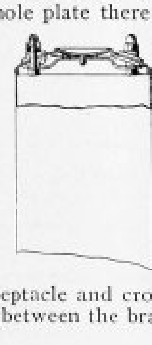
Claim.—In a locomotive, a fire-box, grate bars herein, said fire-box and grate bars placed over the rear sets of driving



wheels and extending on each side beyond said wheels, a barrel containing fire tubes, the ring of which barrel extends between and below the top or apex of the forward sets of driving wheels and a firebrick lined inclined combustion chamber between the fire grate and the tube sheet of the barrel.

883,096. MANHOLE COVER. Harry Del Mar, of New York, N. Y., assignor to Boilers & Engineering Company, of Jersey City, N. J., a corporation of New Jersey.

Claim.—The combination with a pressure containing receptacle and the manhole plate therefor, of the spring secured



to the wall of the receptacle and crossing the manhole, and a plate spring arranged between the brace and the manhole plate. Four claims.

880,693. OIL BURNER FOR FURNACES. Ernest H. Peabody, New York, N. Y.

Claim.—An oil burner for furnaces comprising separate oil and steam conduits having mutually opposed openings, a tip having separate outlets for oil and steam located between said openings and means for pressing the ends of said conduits together upon said tip. Six claims.

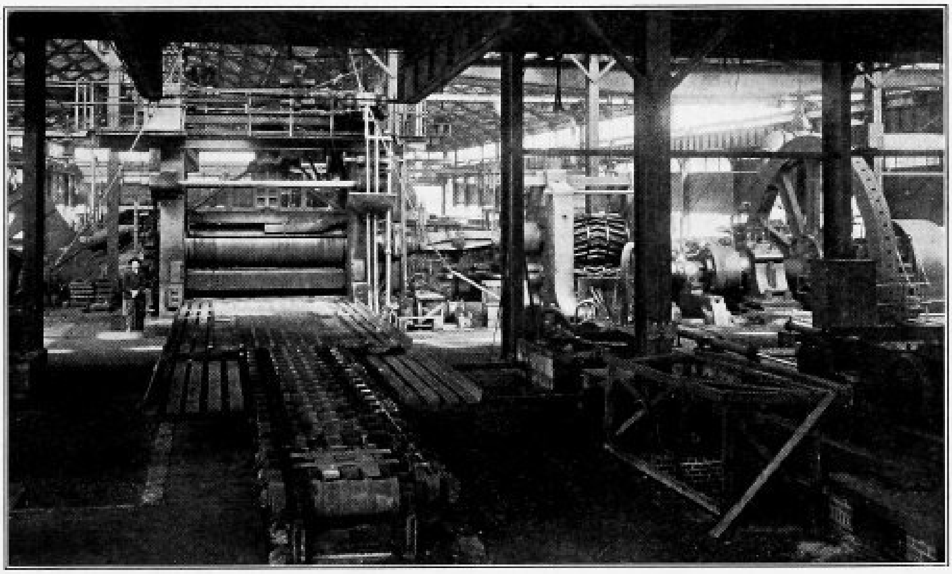
Boiler Shop Equipment and Supply Supplement.

Useful Information About Boiler Makers' Materials, Machinery, Tools and Supplies.*

Materials.

The materials used in making boilers are mild steel, cast steel, wrought iron, cast iron, malleable iron, copper, bronze and brass. Bronze and brass are chiefly used in the fittings applied to boilers, and therefore are not of immediate interest to the boiler maker. Copper is little used in this country, except for small things, such as shims around the ends of boiler tubes; in foreign countries, however, considerable copper plate is used in fire-boxes. It is a better conductor of heat than steel or iron, and therefore is an excellent metal for this purpose. Its disadvantages lie in the fact of its high cost, although this is offset somewhat by the scrap value of the material after it has been used, and also in the fact that it is not as strong as steel, although it is more ductile. Where copper is used in the fire-box, it is common to use copper stays. Copper for either fire-boxes or stays should have a tensile strength of about 34,000 pounds to the square inch, and should have an elongation of from 20 to 25 percent in 8 inches. The use of copper for piping is fast becoming a thing of the past, as it is being superseded by wrought iron and steel.

By far the most important material used in boiler making is, of course, iron in some of its many forms. In the early days of boiler making wrought-iron plates were used almost exclusively; later, when the open-hearth process of making mild steel was invented, it was found possible to make steel of uniform, reliable quality as cheap or cheaper than wrought iron, and so to-day mild steel is the principal form in which iron is used in boilers.



152-INCH PLATE ROLLS AT WORTH BROS. CO., COATESVILLE, PA.

The first process in the production of mild steel from iron ore is the reduction in the blast furnace of the ores into their two principal components, viz.: metallic minerals and gangue or non-metallic minerals. Nearly all iron ores are essentially oxides, which contain from 40 to 70 percent of iron. The remainder of the ore is some non-metallic mineral such as quartz, clay, salt, limestone, etc.

Of the world's production of ore in 1900, the United States produced over 30 percent, the largest portion of which comes from Minnesota (about 38.4 percent of all the iron ore produced in the United States is from Minnesota mines); next comes Michigan with about 33.4 percent; and then Alabama with 7.21 percent; and Pennsylvania with 3.6 percent; other States produce only comparatively small quantities.

Most of the ores in this country do not require any preparation before they can be used in the blast furnace, except occasionally some forms must be crushed to suitable size. In other countries it is sometimes necessary to remove the impurities by crushing, or to roast the ore in order to make it porous, or burn it in order to drive off volatile matter.

The first product obtained from the ore is pig iron, a product totally unfit for structural purposes, as it contains a large percentage of impurities, which impair its physical properties, such as tensile strength, elongation, ductility, etc. The principal impurities in pig iron are carbon, phosphorus, sulphur, manganese and silicon. The amount of these various impurities which is removed in the different processes of

* No attempt has been made in this supplement to illustrate and describe all of the many different types of machines now in the market for boiler makers. It is intended simply to point out the essential features of different classes of machinery. For detailed information send for catalogues to the manufacturers listed in our Buyers' Directory or Boiler Shop Equipment and Supply Directory, issued separately, vest-pocket size, and sent upon application.

manufacturing steel determines the grade and quality of the steel and its suitability for different purposes.

A sectional view of a blast furnace, in which pig iron is made, is shown in the illustration. It consists essentially of a brick stack, usually 70 to 100 feet high, and from 18 to 23 feet in diameter at the largest part, inclosed in a sheet steel casing. Into this stack from the top are charged alternate layers of ore, fuel and flux. The ore, as we have already seen, is some one of the many oxides of iron. The flux is usually limestone or dolomite, and the fuel either charcoal, coke or anthracite coal, coke being the one most frequently used. At the lower part of the furnace, air heated to a temperature of 2,500 or 3,000 degrees F. is blown through openings called tuyeres. This air entering the smallest part of the furnace (called the crucible or hearth) under pressure, gradually loses its velocity as it ascends, due to the widening of the stack at the point called the bosh. By the time the gases have ascended to this height, they have caused the combustion of the fuel and deoxidized the ore. In the upper part

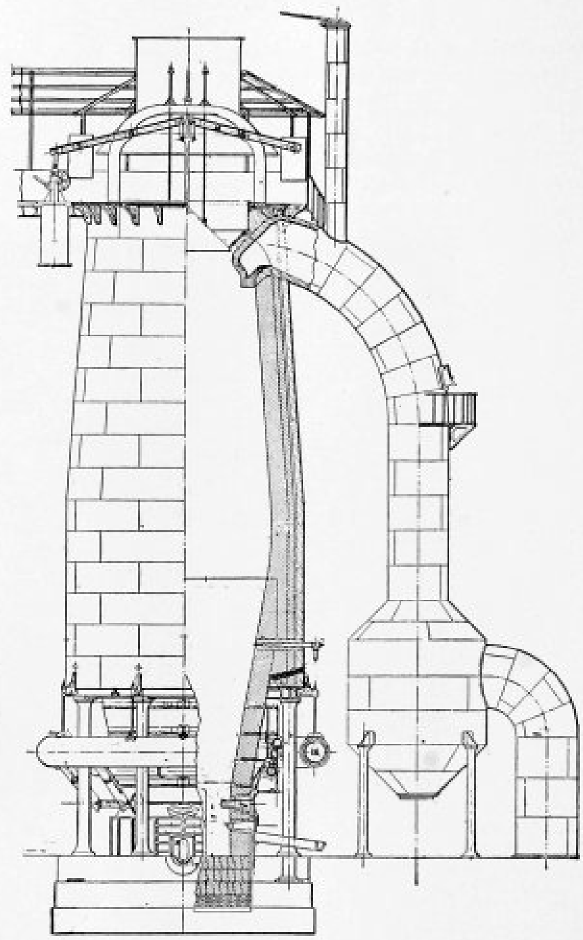
PLATE MILL, STRAIGHTENING ROLLS AND GUILLOTINE SHEARS AT WORTH BROS., COATESVILLE, PA.

of the furnace the gases have become more or less cooled and active combustion is not in progress. The gases are taken off from the top of the furnace and led through a large pipe called the "down-comer" into a device known as the "dust catcher," where most of the dust is removed from it. From the dust catcher it is carried through large pipes to stoves in which it is burned to heat the air which is delivered to the furnace at the tuyeres, or to the boilers which provide steam for the blowing engines which supply the air for the furnace, or it may be used directly in gas engines for blowing the air through the furnace.

The stoves in which the air is heated before it passes to the furnace are large sheet-iron stacks similar in appearance to the blast furnace itself and filled with refractory material such as brick. The gases coming from the blast furnace are consumed in the stoves, heating the brick to incandescence, after which the gases are shut off and the air is blown through the stoves in the opposite direction, taking up the heat from the incandescent brickwork. This operation is reversed as often as the stoves are heated up and cooled off.

The melted iron in the blast furnace is removed from the furnace through a tap hole in the crucible. The molten slag being lighter than the iron, floats on top and is drawn off through slag or cinder notches. The melted iron is allowed to run into previously prepared molds, so that it is formed into short bars of convenient size for handling. These molds are called "pigs," and hence the iron is called "pig iron."

Cast iron is made directly from pig iron by melting it in a stack or furnace and pouring it into suitable molds. Cast iron varies in structure and composition according to the fuel with which it is made, and according to the use to which it is intended to be put. It is brittle and has a tensile strength running from only about 12,000 to 20,000 pounds per square inch. Its compressive strength is frequently as high as 80,000 pounds to the square inch, and therefore is chiefly used in places where it must withstand only a compressive stress. It has been frequently used for parts of sectional boilers and



SECTIONAL VIEW OF BLAST FURNACE SHOWING DOWNCOMER AND DUST CATCHER.

for different fittings. Recently, however, it has been found possible to manufacture cast steel of uniform grades which can better withstand severe temperature changes and stresses which occur in boilers, and therefore it is likely that cast iron will entirely disappear in boiler construction.

In the early days of boiler making, wrought-iron plates were used exclusively. The fact that this material will stand considerable abuse in working; that is, when being flanged or otherwise formed for various parts of boilers, has led many to claim that it is the best material which can be used for boiler construction, even at the present day. Such claims, however, are not substantiated by fact, since mild steel of good quality can be produced and is used almost universally, seemingly as little care being used in handling it as is the case with wrought iron.

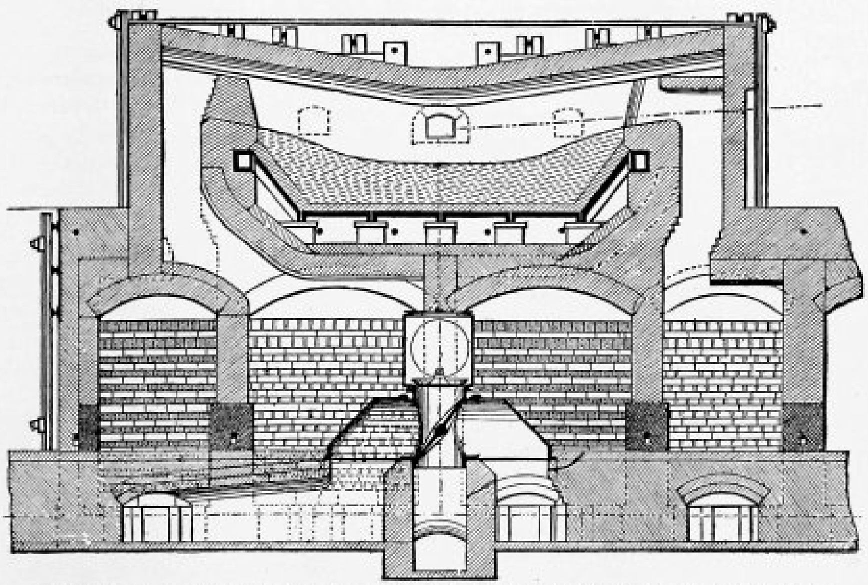
Wrought iron is made by the so-called puddling process, a process which consists principally in melting cast iron in a reverberatory furnace where it is exposed to the reducing action of the oxygen in the flames, and also the reducing action of iron ores or ferric oxides which are placed in the furnace. The metal is stirred constantly by mechanical means in order to bring as much of the metal as possible into surface contact with the flames. The charge in the furnace, after having been decarburized the desired amount, is removed from the furnace in a puddled ball and cast into ingots.

The main object of this process is, of course, to reduce the percentage of carbon and silicon in the cast iron, leaving a product practically free of silicon and containing a small percentage of carbon. Due to its method of manufacture, wrought iron contains considerable slag, which cannot be wholly worked out in the process of rolling the ingot into bars or plates. Particles of slag thus contained in the metal are lengthened out in the process of rolling forming seams, which tend to destroy the homogeneity of the plate.

Practically all boiler plate used to-day is required to be of mild steel, made by the open-hearth process. In the manufacture of mild steel by the open-hearth process, a reverberatory furnace is used, but instead of making use of the flames from a direct-fired coal or coke furnace, producer gas is used. Very high temperatures are obtained by the use of regenerative furnaces, in which the hot gases from the furnace are passed through chambers filled with a checker work of fire-brick which absorbs the heat from the waste gases, being itself raised to a high temperature. After the furnace has been heated in this way, the hot gases are turned off and the gas which is to be burned in the open-hearth furnace is passed through the chamber, taking up the heat from the brickwork. In this way the gases which are to be burned in the furnace enter the furnace at a very high temperature.

An open-hearth furnace is lined with either magnesite or dolomite. Cast iron and steel scrap and some ore are charged into the furnace, and, due to the deoxidizing action of the hot gases, carbon and silicon are reduced. This action is kept up until the desired percentage of carbon is left in the steel. Sometimes a rich oxide of iron is added to the charge after the greater part of the carbon has been removed. If a basic lining, such as limestone, is used in the furnace, pig iron containing a comparatively high percentage of phosphorus may be used, since the phosphorus is reduced by the presence of the basic slag. In this case, lime is also added to form a basic slag and prevent the destruction of the lining. If a basic lining is not used in the furnace, the steel produced is called acid open-hearth steel. In this case it is necessary to use pig iron containing only a small percentage of phosphorus, since there is nothing in this process which tends to reduce the amount of phosphorus in the metal.

The steel is poured from the open-hearth furnace into a ladle, or is taken to a large receptacle, called a "mixer," in which the contents of various heats are placed, in order to give a uniform structure to the steel produced in the mill. From the ladle or from the mixer the metal is poured into ingot molds, after which it is reheated and rolled into blooms, bars and plates.



SECTIONAL VIEW OF OPEN-HEARTH FURNACE, SHOWING REGENERATIVE CHAMBERS UNDERNEATH.

Boiler Plate.

The reduction of the ingots to plates and bars is accomplished by passing them between two rolls, mounted one over the other, both being driven by an engine powerful enough to do the work. The rolls revolve in opposite directions, so that the lower side of the top roll and the upper side of the lower roll travel at the same speed in the same direction. The ingot or the slab is placed between the two rolls, which, as they revolve, draw it forcibly through under an enormous pressure. The squeezing action of the rolls on the exterior surface of the ingots greatly improves the quality of the steel by bringing the particles in more intimate contact, thus removing any looseness of texture and making the mass more homogeneous. For rolling plates, the rolls are plain cast-iron cylinders, but if shapes, such as angles or channels are wanted, the rolls are grooved so as to give the proper section.

A rolling mill may be either a "two high," "three high," "reversing," "non-reversing," or "universal." The type of rolling mill which is most widely used and which has been brought to the highest state of perfection, is the "three-high mill." In the three-high mill there are three rolls in the same vertical plane; the middle roll is smaller in diameter than the other two. The top and bottom rolls are both driven by the mill engine, but the middle roll is driven by the friction of the other two. The middle roll is connected at each end with a hydraulic cylinder so that it may be raised or lowered to enable the plate to enter alternately above and below it. The top and the bottom rolls of the three-high mill shown in the photograph are each 48 inches diameter, and the middle roll is 20 inches diameter. The distance between the housings is 152 inches, so that with little trouble plates can be rolled that are 148 inches in width. These rolls are installed at the plant of

Worth Brothers' Company, Coatesville, Pa., and are the largest in America.

In front of and behind the rolls there is a movable live roller table, which consists of a number of hollow cast-iron cylinders held in suitable bearings, which are fastened on a long rectangular frame. The table, as a whole, is hinged about the end farthest from the mill, and is so connected to hydraulic cylinders that the end nearest the mill may be raised or lowered to allow the ingots or the plates to pass between the top and the middle or the bottom and the middle rolls as may be desired.

Plates may be rolled in the plate mill direct from the ingot, or the ingot may be first broken down into a bloom or a slab in the slabbing mill. An ingot which has been rolled in a slabbing mill until its section is nearly square is called a bloom. Blooms are used for rolling large plates and shapes, and also in the production of large forgings. A slab is a reduced ingot having a rectangular cross-section; they are used for rolling plates. The steel in the top and bottom portions of an ingot is inferior in quality to that found in the central part, and by rolling the ingots into long slabs, the ends can readily be sheared off and used for scrap, or else rolled into a low grade of steel, thus leaving only the best part of the ingot to be rolled into boiler plate, etc., where a good quality of steel is required. Another advantage of rolling into slabs is that the steel is worked more and becomes more homogeneous.

After rolling, the plates are straightened, stamped, sheared and carefully inspected.

American Steel Manufacturers' Standard Specifications for Special Open-Hearth Plate and Rivet Steel.

Chemical Properties—Flange or boiler steel: maximum phosphorus, .06 per cent; maximum sulphur, .04 percent.

Extra soft and fire-box steel: maximum phosphorus, .04 percent; maximum sulphur, .04 percent.

Physical Properties—Special open-hearth plate and rivet steel shall be of three grades: extra soft, fire-box, and flange or boiler steel.

Extra Soft Steel—Ultimate strength, 45,000 to 55,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, 28 percent.

Cold and quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

Fire-Box Steel—Ultimate strength, 52,000 to 62,000 pounds per square inch.

Elastic limit, not less than one-half the ultimate strength.

Elongation, 26 percent.

Cold and quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

Flange or Boiler Steel—Ultimate strength, 55,000 to 65,000 pounds per square inch.

Elastic limit not less than one-half the ultimate strength.

Elongation 25 percent.

Cold and quench bends, 180 degrees flat on itself, without fracture on outside of bent portion.

Boiler Rivet Steel—Steel for boiler rivets shall be made of the extra soft grade.

Modifications in Elongation for Thin and Thick Material—For material less than 5/16 inch, and more than ¾ inch in thickness, the following modifications shall be made in the requirements for elongation:

For each increase of ⅛ inch in thickness above ¾ inch, a deduction of 1 percent shall be made from the specified elongation.

For each decrease of 1/16 inch in thickness below 5/16 inch, a deduction of 2½ percent shall be made from the specified elongation.

In rounds of ¾ inch or less in diameter, the elongation shall be measured in a length equal to eight times the diameter of section tested.

Variation in Weight—The variation in cross-section or weight of more than 2½ percent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ percent variation above or 2½ percent below the theoretical weight. When 100 inches wide and over, 5 percent above or 5 percent below the theoretical weight.

Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

Up to 75 inches wide, 2½ percent above or 2½ percent below the theoretical weight; 75 inches wide up to 100 inches wide, 5 percent above or 3 percent below the theoretical weight. When 100 inches wide and over, 10 percent above or 3 percent below the theoretical weight.

Table of Allowances for Overweight for Rectangular Plates When Ordered to Gage.

Plates will be considered up to gage if measuring not over 1/100 inch less than the ordered gage.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 pound:

PLATES ¼-INCH AND OVER IN THICKNESS.

Thickness of Plate.	Width of Plate. Up to 75 Inches, Percent.	75 Inches to 100 Inches, Percent.	Over 100 to 115 Inches, Percent.	Over 115 Inches, Percent.
1/4-inch	10	14	18	..
5/16-inch	8	12	16	..
3/8-inch	7	10	13	17
7/16-inch	6	8	10	13
1/2-inch	5	7	9	12
9/16-inch	4½	6½	8½	11
5/8-inch	4	6	8	10
Over 5/8-inch	3½	5	6½	9

PLATES UNDER ¼-INCH IN THICKNESS.

Thickness of Plate.	Width of Plate. Up to 50 Inches. Percent.	70 Inches to 70 Inches, Percent.	Over 70 Inches, Percent.
1/8 up to 5/32-inch	10	15	20
5/32 up to 3/16-inch	8½	12½	17
3/16 up to 1/4-inch	7	10	15

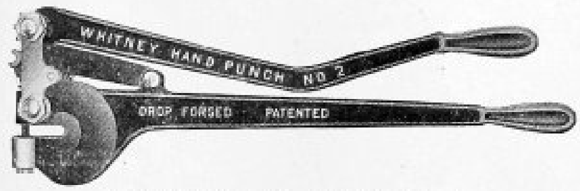
Machinery.

Punches.

A punch is an indispensable tool in a boiler shop. On work which does not require great accuracy, it affords a rapid means of putting in the rivet holes. Since the operation of punching tends to injure the metal in the immediate vicinity of the hole, it is desirable on most boiler work, and on tanks intended for high pressure, to drill the rivet holes instead of punching them. Even in shops where most rivet holes are drilled, the punch is still in almost continual operation; for it can be used for cutting out manholes, handholes, or other irregular openings in the plate by punching a row of overlapping holes. This, of course, leaves a ragged edge which must be chipped off.

The exact effect which punching has upon mild steel plates is hard to determine. It tends to decrease the ductility of the metal or make it brittle. In thin plates it probably has no effect upon the strength of the material, but in plates over a half inch thick there may be a loss of from 11 to 33 percent in the strength of the plate. On the other hand, when rivet holes are drilled, the metal around the hole is not injured, and the strength of the material between rivet holes may appear even stronger than before the holes are drilled. This is due to the fact that the material between the holes has the form of a grooved specimen in which the metal is prevented from stretching, and therefore shows a somewhat higher tensile strength than a plain bar, which is free to stretch.

Punches are divided into different classes, according as they are driven by hand, by hydraulic power or by being

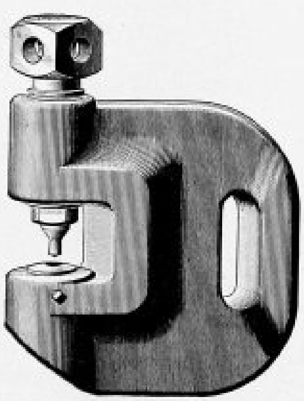


HAND PUNCH.—W. A. WHITNEY MFG. CO.

geared to an electric or steam motor. For very light material, small, lever hand punches are frequently used. The means of obtaining a heavy thrust on the punch varies in different makes, and include such devices as toggle joints, roller and wedge, swinging lever, etc. A common form is also a screw punch, and although considerable power can be obtained with this punch, it cannot be operated as rapidly as other kinds.

Hydraulic punches usually consist of a large cast-iron frame in the form of jaws. In the lower jaw the die is placed, and in the upper jaw the punch is attached to a movable plunger. The plunger is joined to a piston, working in a vertical cylinder in the head of the machine. Suitable valves control the supply of water to this cylinder, and thus the power is applied directly to the punch. A smaller cylinder is usually provided for returning the plunger after its working stroke.

Ordinary power punches consist of a frame similar to that used for a hydraulic punch. In this case, however, the plunger



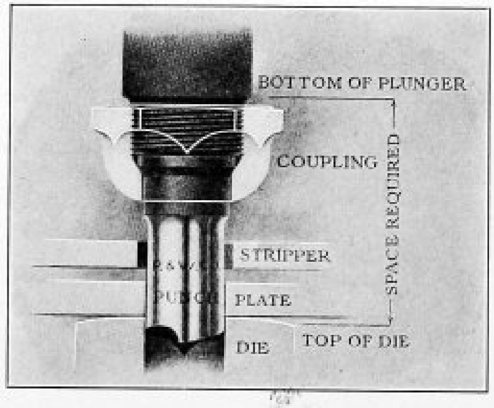
SCREW PUNCH.—A. L. HENDERER'S SONS.

receives its motion from a horizontal eccentric, or cam shaft, which is joined by a clutch to another shaft, on which is placed a flywheel and spur gear. The power is transmitted to this shaft from a countershaft through gears. The countershaft may be driven either by belts on a fast-and-loose pulley, or by a steam engine direct connected to the shaft, or by an electric motor direct connected. The flywheel is driven at a speed sufficiently great to give it an amount of energy capable of driving the punch through a working stroke without too great diminution of speed.

For punching holes in the flanges of boiler heads, or other plates, a horizontal punch is used in which the plunger and punch are flush with the top of the machine.

One of the greatest objections to punching rivet holes is the fact that the punch cannot be accurately centered, and therefore the holes are liable not to be fair. This may be overcome by the use of a spacing table on which the plate which is being punched is allowed to rest. A templet fastened to this table, on which the spacing of rivet holes is marked by pegs, serves to guide the carriage on which the plate is held. This carriage can then be moved ahead a space at a time, giving accurate spacing of the rivet holes which automatically allow for any stretching in the material due to the punching.

Spacing tables can be used for punching the seams on the

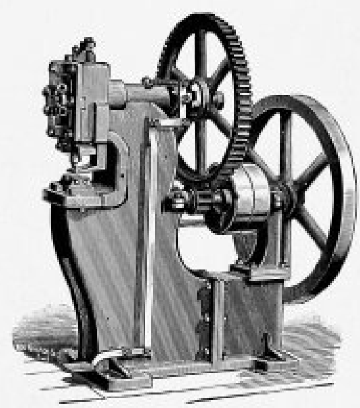


PUNCH, DIE AND COUPLING. PRATT & WHITNEY CO.

long side of a plate, but cannot be used for the end of a plate. To punch an entire row of rivets in the end of a plate, multiple punches are used, on which the plunger is provided with a punch for every hole in the seam, the punches being arranged for the proper spacing. Multiple punches frequently have adjustments so that punches may be arranged in groups for punching the holes for bracket plates, butt straps, etc.

The chief objection to either multiple punches or spacing tables is that they require a considerable amount of time for their adjustment, and therefore are suitable for use only on duplicate work, such as occurs in the construction of large tanks, blast furnaces, etc.

The punch itself is made of a solid piece of tool steel, and is held off the flange by means of a coupling, as shown above. Punches are made in various shapes, the most convenient being a flat punch. The relative size of the punch and die has an appreciable effect on the power required to do the

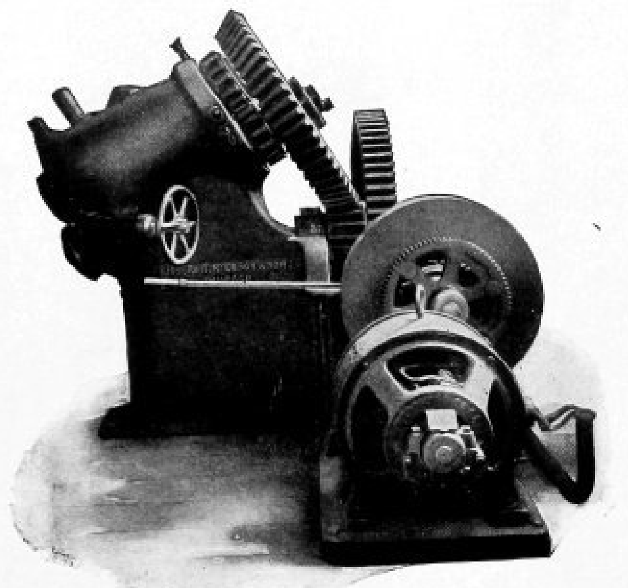


POWER PUNCH.—CINCINNATI PUNCH & SHEAR CO.

punching, and upon the smoothness of the hole in the plate. The usual dimensions allow the diameter of the die to be 1/32 inch larger than the diameter at the tip of the punch, and the diameter at the tip of the punch to be 1/16 inch larger than the diameter at the top, or in the body of the punch. This prevents the punch from binding in the hole on the return stroke. Punches of various different styles are designed to shear the metal from the hole gradually, rather than to shear it all out at once.

Shears.

Shears are usually made of the same general form as punches, and frequently a machine may be used for both purposes. Punches and shears are also manufactured as duplex machines, the stroke of one machine alternating with that of the other. In order to bevel the edges of plate to give a calking edge, rotary bevel shears have been designed to take



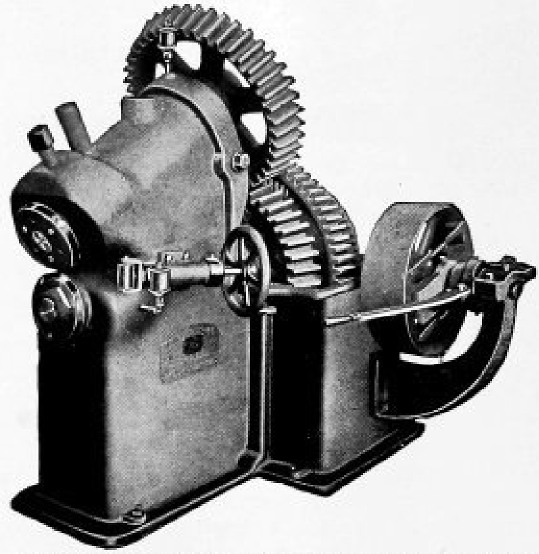
LENNOX ROTARY BEVEL SHEARS.—JOS. T. RYERSON & SON.

the place of plate planers. These shears have the advantage that they can bevel the curved edge of a plate, whereas the planer can bevel only a straight edge. The Wangler rotary bevel shears shown in the illustration, placed on the market by the Scully Steel & Iron Company, of Chicago, have the cutter shafts arranged in such a manner as to throw the cutting strains at right angles to the bearings. The top cutter has a flush fastening, so that angles of equal legs can be beveled without interference. Both cutters are reversible and have two cutting edges. The machine can, of course, be driven either by motor or by the belt.

In the Lennox rotary bevel shear, placed on the market by Joseph T. Ryerson & Son, of Chicago, the shafts are arranged in a parallel direction in order to give a proper distribution of the cutting strains. The shafts are themselves driven by bevel gears.

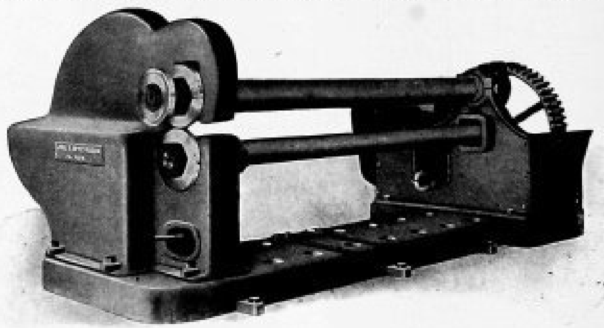
Splitting plates, where the distance from the cut to the edge of the plate is wider than the depth of throat on an ordinary plate shear, can be accomplished by using a splitting shear. Such a machine with rotary cutters is placed on the market by the Scully Steel & Iron Company, of Chicago. The cutters are hardened tool steel discs, the edges of which are milled to make them self-feeding. The cutters can be adjusted vertically to allow for cutting different thicknesses of plate.

The Lennox rotary splitting shear, placed on the market by Joseph T. Ryerson & Son, Chicago, Ill., is designed for straight or curved shearing of plates from No. 16 gage to ¾ of an inch in thickness. It will also cut round, square or flat bars of a diameter or thickness corresponding to the capacity of the tool for plates. The blades are milled to make them self-feeding, while they are so arranged that they will not receive heavier plate than the machine will handle. The machine may be speeded up to cut as fast as the plate can be handled by the operator, while the hold-down wheel attachment prevents the sheet from bending beyond the blades. This machine has the great advantage of having no worm gears or other ineffcient forms of driving mechanism. The principal point wherein this machine differs from other splitters is in the double housing. This not only greatly strengthens the machine, but the shafts and rods connecting the two housings act as a rest for the plates, and save a great deal of time and labor in handling. In a single housing machine, the plate being sheared, is supported by the machine at but one point,



WANGLER ROTARY BEVEL SHEARS.—SCULLY STEEL & IRON CO.

hence it must necessarily bend over or require the services of an additional man to see that it is kept level by means of a hoist. If the plate is allowed to bend over the blades it is impossible to shear accurately. Furthermore, the bending of a heavy plate in a machine is sure to chip the blades. The Lennox machine is just as economical in floor space as single housing tools, because the size of the plate being sheared governs the floor space required. For instance, in splitting a 16-foot plate it is necessary to allow 8 feet on either side of the blades whether the machine has a single or



LENNOX ROTARY SPLITTING SHEARS.—JOS. T. RYERSON & SON.

double housing. On the Lennox splitter there is a projecting upper shaft, on which is fitted a hold-down wheel, which assists further in guiding and keeping the plates level on the blades, and at the same time does away with the services of an extra man to guide the plate through.

A new combination splitting shear and bar and angle shear is now being built by Henry Pels & Co., 68 Broad Street, New York City. Cutting angles, plates, bars, etc., on an ordinary shear causes considerable loss of time in changing knives and adjusting, which is eliminated with this tool. The splitting shear will handle plates of any length or width, and the bar shear can be enlarged to permit the insertion of a set of knives to shear rounds, squares, flats, angles and tees without change. Angles and tees can also be beveled up to 45 degrees, right or left.

The shear is manufactured in seven sizes, with capacities from ⅜-inch to 1¼-inch plates. Capacities and details of the largest size are as follows:

Capacity of plate shear—
- Plates of unlimited length or width, 1¼ inches.
- Flat bars, 5 by 1⅝ inches.

Capacity of bar shear—
- Rounds, 3 inches.
- Squares, 2½ inches.
- Angles, 7 by 7 by ¾ inches.
- Tees, 6 by 6 by ¾ inches.
- Angles at 45 degrees, 5 by 5 by ⅝ inches.
- Number of strokes per minute, 12.
- Length of stroke, 2 inches.
- Length of knife, 16 inches.
- Horsepower required, 14.
- Length, 8 feet.
- Width, 4 feet.
- Height, 8 feet.
- Weight, 17 500 pounds.

The splitting shear can be fitted with longer knives to enable a longer cut in lighter plate. The frame of the shear is a solid rolled steel plate 4 inches in thickness, and is absolutely guaranteed against breakage. No stay-bolts are necessary in shearing the heaviest flat stock on the splitting shear end. The gears are semi-steel of heavy design, bearings are aluminum bronze, and all working parts are forgings; in short, the only cast iron used in the entire construction is the fly-wheel and pulleys. Both the straight and tangent channels through which the sheared sections pass have no fillets, but are milled to sharp corners, and it is claimed there is no cramping or buckling of plates in consequence. There are no gears projecting from either the front or back of the machine. Both the splitting shear and bar cutter can be operated independently by means of gags, and can be adjusted to shear continuously or intermittently.

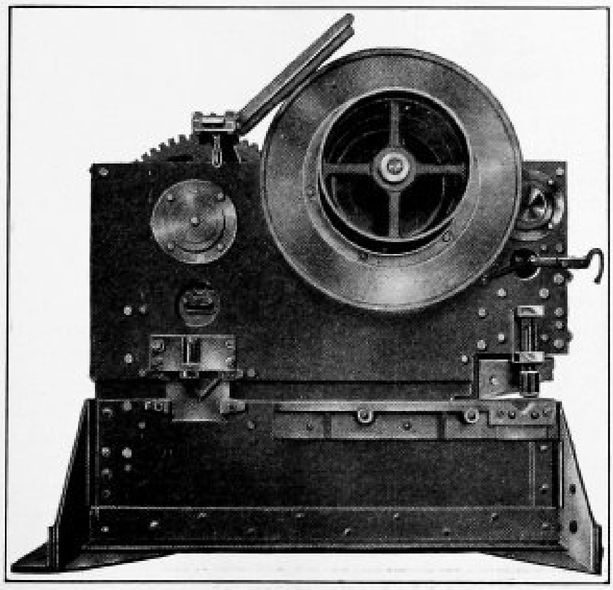
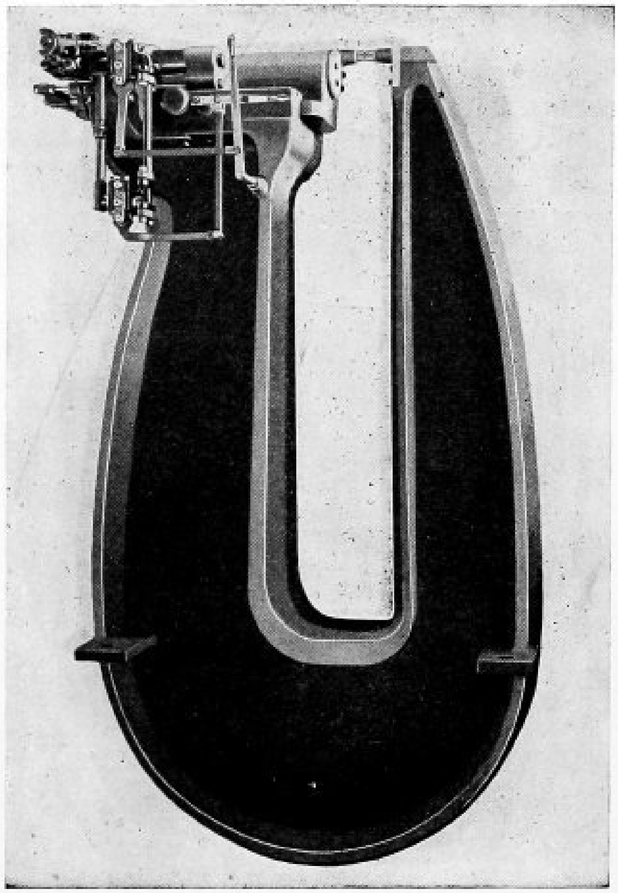


PLATE AND BAR SHEARS.—HENRY PELS & CO.

Riveters.

The earliest forms of riveters were driven by steam. These were soon superceded by hydraulic and pneumatic machines. In general, hydraulic machines are used for stationary installations and pneumatic apparatus for portable riveting.

The riveter shown by the above halftone is the type furnished by the Chambersburg Engineering Company, Chambersburg, Pa., for general boiler-shop work. It is outside hemp, packed throughout, having easily accessible glands. By a patented arrangement three, five or seven multiple pressures may be obtained on the dies, the minimum amount of pressure water being used. This insures the greatest economy. The machine is simple in construction, not liable to get out of order, and it is very quick acting. The halftone also shows the crane, valve and lever attached to the riveter, so that one man is able to operate both the hydraulic crane and the riveter.



HYDRAULIC RIVETER.—CHAMBERSBURG ENG. CO.

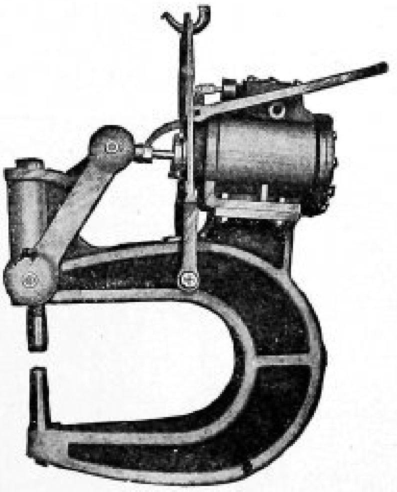
The design and operation of various types of riveters built by John F. Allen, at 370-372 Gerard Avenue, New York, are generally well known, and it is the quality of these tools for boiler, tank and structural iron working purposes that is now of special interest.

A notable record claimed for an "Allen" riveter is as follows: 1,240 ¾-inch rivets in 38 minutes. 10,809 ¾-inch rivets in 8 hours, and 13,589 ¾-inch rivets in 10 hours; this with one operator, one machine, and the result—all good rivets. It has been found that when using an Allen riveter to drive up all the back heads and mud-rings, it is seldom necessary to calk a mud-ring rivet.

The items of pressure, stroke and air are of special interest in connection with the Allen tools, as the following data show:

	8-Inch Cylinder.	10-Inch Cylinder.	12-Inch Cylinder.
Pressure at 90 pounds	30 tons.	45 tons.	65 tons.
Pressure at 100 pounds	35 tons.	50 tons.	75 tons.
Stroke	3½ inches.	3½ inches.	4 inches.
Air consumption per rivet, at 80 pounds	2 cubic feet.	4 cubic feet.	6 cubic feet.

This tool is always designed to give surplus pressure rather than just enough. For example; where a ⅞-inch rivet is the maximum to be driven, statistics show that 45 tons pressure is required to do the work. For such work a 10-inch cylinder



PNEUMATIC COMPRESSION RIVETER.—JOHN F. ALLEN.

riveter with 50 tons pressure is furnished. A surplus pressure exists that insures a uniform pressure at the end of the stroke.

Planers.

In order to give a good calking edge, as well as remove that portion of the plate which has been damaged by shearing the edges, all boiler plates are commonly planed. The planer used for this purpose consists of a long, narrow bed on which the plate is held by screws or hydraulic jacks. The carriage travels any desired length along the bed, the length of travel being determined by the position of adjustable dogs. The carriage is driven by a lead screw, and commonly carries two tools, one for cutting while the carriage is traveling in either direction. The tools are commonly fed by hand.

On some planers a cross-arm is provided at the end of the machine on which one end of the plate can be planed at the same time that the side is being planed. This arm is usually movable, so that it can swing at least 10 degrees on either side of a right angle in order to plane the edge of a plate which is not exactly square. The carriage for planing the end usually cuts while traveling in one direction only.

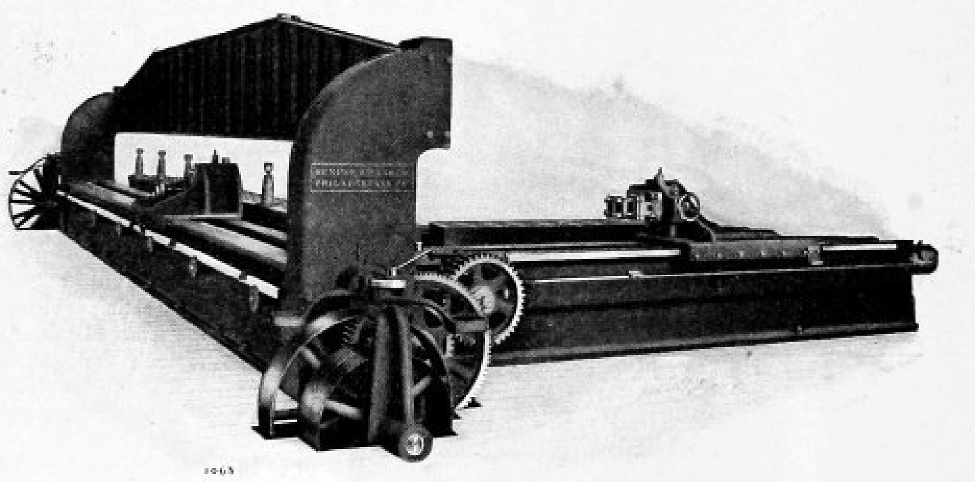


PLATE PLANER.—NILES-BEMENT-POND CO.

Air Compressors.

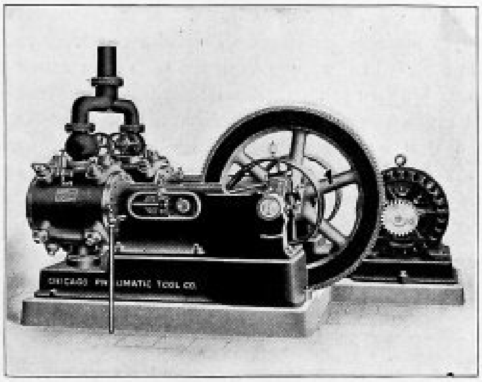
The immense growth in the use of compressed air has brought about a great improvement in the design and consequent efficiency of air-compressing machinery, and the history of this branch of mechanical achievement shows wonderful strides from the old-fashioned, cumbersome, wasteful, unregulated types of compressors to the modern, compact, well proportioned and perfectly governed compressors. The older builders have been forced to abandon obsolete patterns and produce newer designs to keep pace with this progress. The Franklin Compressors, built by the Chicago Pneumatic Tool Company, of Chicago, at their Franklin, Pa., plant, have frames that are heavy box-shaped castings, strongly ribbed, with a large factor of safety to withstand strains when working at maximum load. The bottom surface, bearing upon foundation throughout its entire length, insures stiffness, not only at the main bearing, but also along the guides and at the connection with the cylinder. Being entirely self-contained, expensive foundations are avoided and expert erection services unnecessary.

The steam cylinders have exterior walls covered with asbestos or mineral wool, and are neatly lagged with planished iron. The air cylinders and cylinder heads are completely water jacketed, providing a thorough circulation of water with equal cooling at all points. Pistons are of solid type with cast-iron spring rings. The shaft is of center-crank type with exceptionally heavy crank arms. The box crosshead is provided with taper shoes, turned to fit the cylindrical guide. These shoes have screw adjustment affording a ready means of taking up the slight wear and of securing proper alignment. The piston rod is screwed into the cross-head and secured by a lock nut. The connecting rod is of substantial pattern, with solid cross-head end having wedge and adjusting screws. The single compressor has two balance wheels, one on each side, of sufficient weight to insure smooth operation. Duplex and cross-compound compressors have heavy flywheels made in two sections, securely bolted together at the hub and at the rim.

Steam-driven compressors are provided with a pressure-regulating governor to automatically control the operation of the compressor in accordance with the demand for air, working in connection with a speed governor, which regulates the speed of the compressor. Single steam and belt-driven compressors also have an unloading device to relieve the compressor of all load when the desired air pressure is obtained, and automatically cause it to resume delivery when the receiver pressure becomes reduced. Compressors driven by electric motors by means of belt, gears or chain, or direct connected, are unloaded in the same manner as described for belt-driven compressors.

The smaller steam-driven compressors, with steam cylinders 10 inches in diameter or less, have plain D slide valves accurately scraped to seat and securely fastened to rod with adjustment for wear. Cylinders 12 inches diameter or larger are provided with Meyer adjustable cut-off valves, the main valve being balanced to relieve the strain upon all valve gear parts. The balance plate and steam chest cover are both designed to provide the necessary rigidity to prevent their deflecting under the steam pressure and thus causing leakage. A graduated scale indicates the point of cut-off which may be adjusted from ¼ to ⅞ of the stroke while compressor is running.

The air inlet valves are of poppet type and have removable seats and guides, and are thoroughly guarded from entering cylinder in case of breakage. They are placed radially in the cylinder for accessibility, a feature of much importance, for



FRANKLIN AIR COMPRESSOR.

the valves sustain the severest service of air compression and the heat incident thereto. Should the valves cease to perform their proper functions, the compressor is either wholly or partially disabled until the trouble is remedied. The valve seat is a part entirely separate from the cylinder proper and may be removed, replaced or renewed whenever occasion requires. The valve and seat form a complete piece of mechanism which may be examined, reground and adjusted separate from the compressor. They are placed in position after the heads are attached to the cylinder, and are held securely by large screw plugs. As the heads need not be removed it is but a moment's work to take out a valve. The valve springs are of steel, light enough to minimize resistance in opening, yet strong enough to promptly seat the valve in closing.

To meet the objections sometimes offered against a numerous complement of poppet valves, compressors of larger size are also built with mechanically moved intake valves of semi-rotary Corliss type, placed in the cylinder heads and driven by gear from eccentrics on the main shaft. They open and close without impact and are therefore free from the hammering and wear incident to poppet valves.

The intercooler, provided with two-stage compressors, forms part of the compressor base, being located directly under the air cylinders, minimizing piping and floor space and rendering the compressor with its intercooler completely self-contained. The intercooler tubes are of brass or charcoal iron expanded into steel tube sheets. Ribs are provided in the water heads, and baffle plates are inserted between the tubes, insuring complete circulation of both water and air.

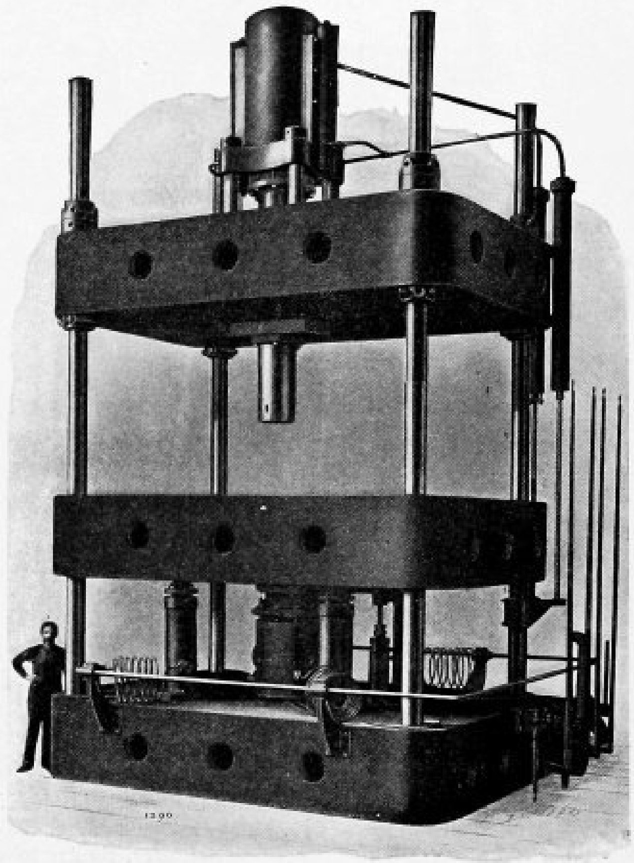
Sight-feed lubricators of exceptional size are provided for steam and air cylinders; wiper oilers for crank-pin bearings, grease cups for valve gear, and oil cups of approved pattern and adequate size for all wearing parts. Larger sizes are provided with a gravity oiling system for all principal bearing surfaces.

Flanging Machines.

Hand flanging is done with the aid of hand clamps, which consist of two housings in which suitable formers can be placed, and above which a clamp is used to hold the plate in position. The upper clamp may be forced down by means of screws, air or hydraulic cylinders.

The most common form of power-flanging machine is the sectional flanger, which consists of two vertical hydraulic cylinders and one horizontal cylinder, all placed to operate on the work which is held on dies or formers. The work can be held on the die by one of the vertical plungers, while the other turns over the flange. The horizontal plunger is then forced against the flange, smoothing it to the desired shape.

Hydraulic presses, similar to the one shown in the illustration, which is the product of the Niles-Bement-Pond Company, Philadelphia, Pa., are largely used. In these machines it



HYDRAULIC FLANGING PRESS.—NILES-BEMENT-POND CO.

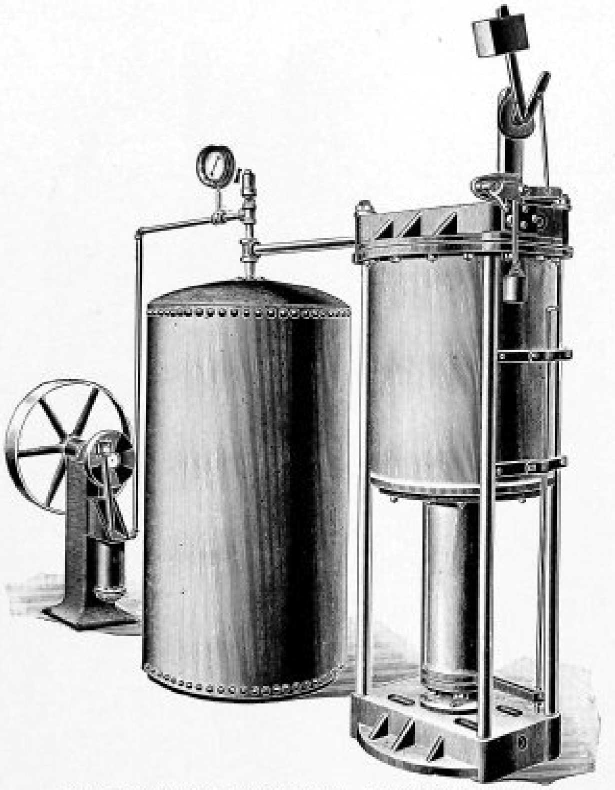
is necessary to have separate dies or formers for each piece of work, and the size of the work which can be flanged is limited by the size and capacity of the machine. For flanging circular heads, a rotary flange or spinner is sometimes used. In this machine the circular plate is held between revolving disks, while the flange is turned down by means of movable rollers.

Pumps and Accumulators.

The fluid pressure utilized in hydraulic machinery is produced in the first place by pumps, the force subsequently being transformed in the cylinders of the presses or intensifiers or stored in accumulators. Such pumps are operated either by hand or by steam power, turbine or electric motors. Direct-acting steam pumps are used to a great extent. For hydraulic jacks and for testing apparatus, hand pumps are generally used, and with such pumps the proportion between the plunger and lever is often so great that one man can develop a pressure of more than 10,000 pounds per square inch.

The fluid pressures used in hydraulic machinery are selected with reference to the nature of the work to be performed and the style of machines in which they are to be used. Pressures between 100 pounds and 500 pounds per square inch are considered as low pressures, while for large plants, pressures ranging from 500 to 2,500 pounds per square inch are generally employed. For some styles of hydraulic presses the accumulator pressures reach 3,500. The pump does not often deliver its pressure directly to the press, the accumulator being interposed between the pump and the operating machine.

The accumulator serves a double function, the principal purpose being to store up the hydraulic power, while incidentally its motion is caused to control the starting and stopping of the pumps by which it is served. After being once started, a pump and accumulator equipment is generally designed to continue in action automatically, regulating itself without further attention. The ordinary hydraulic accumulator consists of a hydraulic cylinder and plunger, similar to a hydraulic press. It is loaded with weights equal to the total hydraulic pressure due to the pump pressure.



HYDRO-PNEUMATIC ACCUMULATOR.—WATSON-STILLMAN CO.

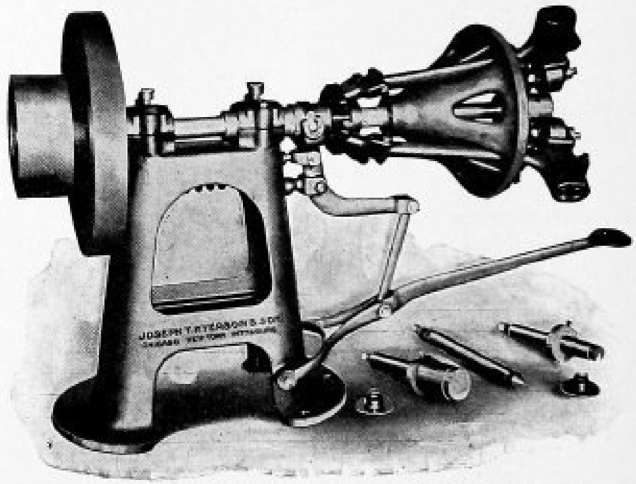
Variation in accumulator pressure is effected by a simple arrangement by which one or more weights can be left on the ground when the accumulator ascends. Although many accumulators are of the weighted-plunger type, yet the plunger may be stationary and the weights attached to a moving cylinder, and this form is frequently used in practice.

In order to avoid the shocks which occur with the weighted accumulator the hydro-pneumatic accumulator has been designed. In this apparatus the accumulator proper consists of a hydraulic plunger and its cylinder, connected to a large piston, which works in an air cylinder. The air cylinder is in direct communication with a large air reservoir, so that the expansive force of the compressed air takes the place of the weights in the ordinary accumulator, the air pressure on the large piston opposing the hydraulic pressure on the smaller plunger. When the accumulator rises, the air is compressed, and when the accumulator descends the air expands. The air reservoir is made of such a size that the variations in pressure do not exceed 5 percent of the working pressure; the air pressures in this style of accumulator generally range from 150 to 250 pounds per square inch, the hydraulic pressure depending upon the ratio between the areas of the air piston and the hydraulic plunger. The great advantage of this style of accumulator is the absence of inertia shocks, owing to the absence of heavy weights. It also has the great advantage that the hydraulic pressure can be varied simply by blowing out some air when it is desired to reduce the pressure, or by increasing the air pressure when a higher hydraulic pressure is required.

The illustration shows a hydro-pneumatic accumulator manufactured by the Watson-Stillman Company, of New York.

Flue Welders.

The Ryerson flue welding machine, handled by Joseph T. Ryerson & Son, Chicago, which is of the roller type, consists of a heavy substantial base on which a revolving shaft is mounted in suitable bearings. This shaft carries the driving pulley and fly-wheel at one end, while at the other end, and continuous with it, is an internal roller-carrying mandrel, this mandrel much resembles the ordinary roller type of flue expander, and it is designed to roll the inside of the tube during the welding process. A steel head and arms carrying large adjustable rollers revolve with the shaft, the rollers being disposed equidistant and in the same vertical plane with the mandrel rollers. By pressing the foot treadle, shown in the illustration, the outside rollers are brought down toward the mandrel rollers until they are only separated from them by the thickness of the tube wall. The arrangement of the four rollers is such that they can be accurately and quickly adjusted by anyone, and as this is the only adjustment necessary this machine is easy to operate.



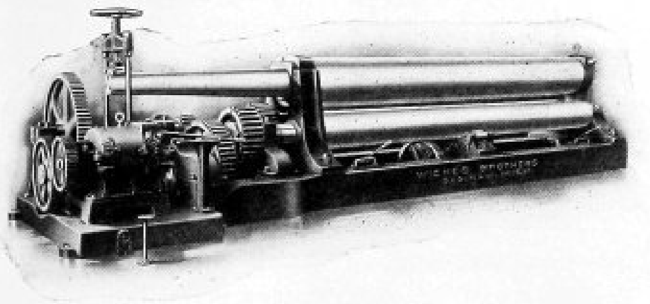
ROLLER FLUE WELDER.—JOS. T. RYERSON & SON.

While welding with this machine both hands are free to handle the tubes. In addition to welding, this machine will scarf, swedge or cut off tubes as desired, by simply removing the roll mandrel and substituting the proper scarfing rolls, swedging device or cutting wheels.

A different type of flue welder, placed on the market by the Scully Steel & Iron Company, Chicago, is known as the McGrath pneumatic flue welder. This consists of vertical air cylinders, which operate hammers designed to strike about 2,000 blows per minute. The flues are held over a stationary mandrel, while the hammer closes the weld. The machine will scarf both safe and flue end, and swedge the tubes for welding.

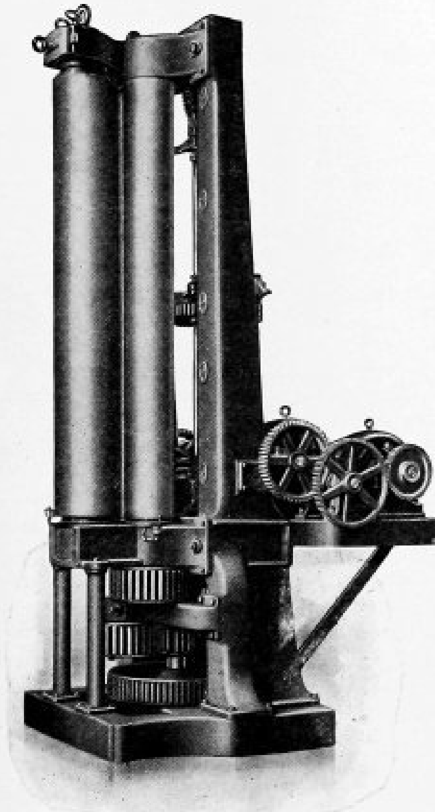
Bending Rolls.

The illustrations of plate bending rolls show two types of machine manufactured by Wickes Bros., Saginaw, Mich.



HORIZONTAL BENDING ROLLS.—WICKES BROS.

The power is applied through a train of heavy gearing, proportioned in each case for the work to be done. In the horizontal type the pyramidal style of tool is the one most used



VERTICAL BENDING ROLLS.—WICKES BROS.

in which there are two lower rolls and one larger upper roll located centrally above. This form allows the plates to be fed in from either side with equal facility. For special requirements machines are built having two rolls, one fixed directly above the other and geared together, and a third, or bending roll, swinging up at the side. The outer housing is ordinarily of the opening type, wherein the upper bearing may be removed and the housing opened to allow the removal of a plate rolled to a complete circle. In this case the opposite end of the upper roll is extended in taper form and provided with hand-wheel or other means for depressing the balance bar, and thus supporting the outer end of the roll while the housing is open.

In the vertical roll, which is of special value in the manufacture of large marine boilers, the weight of the plate is supported entirely by the housing of the tool, leaving the rolls free to bend the plate, which is readily brought to a true circle. The upper end of the outer roll is secured by a hinged housing, which can be swung upward to allow the removal of the plate when rolled to a complete circle.

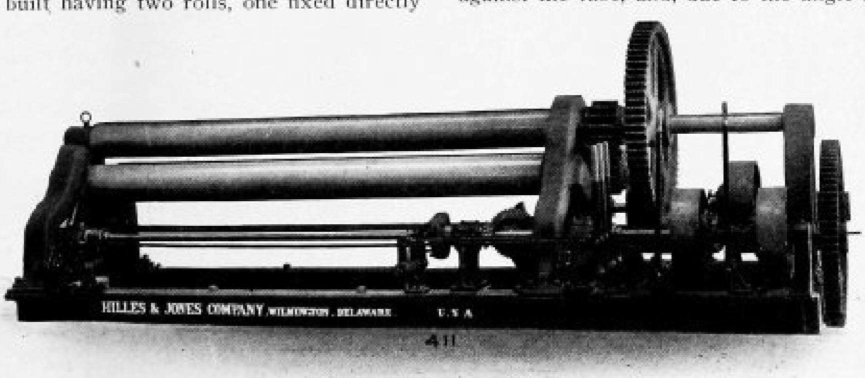
While the illustrations show motor-driven machines, many tools are built to be operated by belt or twin engines. The machines are built in varied sizes and types, to best suit the requirements of the work to be done.

A special style of plate bending rolls is manufactured by the Hilles & Jones Company, Wilmington, Del., by means of which it is claimed plates can be bent clear to the edge. This is impossible with ordinary machines where the rolls are arranged in pyramid form. In the Hilles & Jones machine two of the rolls are placed vertically in line, the bending being done by a side bending roll operated in inclined ways on the housings. The machine may be driven either by duplex friction clutch pulleys for belt driving or by direct-connected motors or steam engines.

Tools.

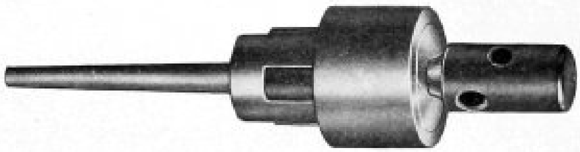
Expanders.

Tube expanders are of two general types—roller and prosser or sectional. The roller expander consists of three or more small rolls placed at an angle in a frame through which a taper pin is forced. By turning the pin the rolls are forced against the tube, and, due to the angle at which they are set,



SPECIAL BENDING ROLLS.—HILLES & JONES CO.

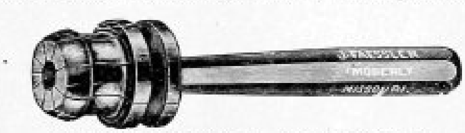
cause the pin to be fed into the expander. Different makes of expanders differ in various details. The Nicholson expander, manufactured by W. H. Nicholson & Co., Wilkesbarre, Pa., has six rollers with spherical heads, which form ball and socket joints in the frame, so that the rolls are free to turn either way. In the expander manufactured by the A. L.



ROLLER EXPANDER.—J. FAESSLER MFG. CO.

Henderer's Sons, Wilmington, Del., the thrust ring is threaded to the body and may be adjusted to allow the tube to project any desired length.

Sectional expanders consist of several segments held together by a spring; the inside of the segment forms a straight hollow cone into which a steel taper pin fits. The expander is forced into the tube and expanded by driving in the pin with

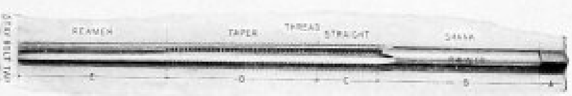


SECTIONAL EXPANDER.—J. FAESSLER MFG. CO.

a hammer. The form of the segments is such that a collar is formed in the tube just inside the tube sheet. Some forms of sectional expanders, such as the Lucas, handled by the Scully Steel & Iron Company, Chicago, bead the flue at the same time that they expand it. In the Faesler expander, shown in the illustration, which is manufactured by the J. Faessler Manufacturing Company, Moberly, Mo., the tapered mandrel is replaced by an octagon tapered pin to increase the bearing surface on each section of the expander.

Staybolt Taps.

Stay-bolt taps are usually made so that the end of the tool is in the form of a reamer, this being followed by a tapered thread and finally by a straight threaded portion. Special

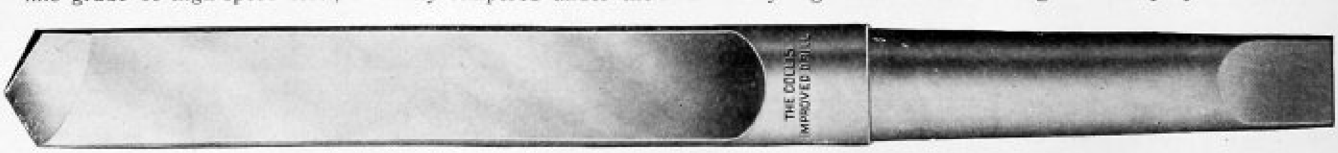


STAYBOLT TAP.—PRATT & WHITNEY CO.

forms of taps, known as spindle taps, are also made for retapping stay-bolt holes from the inside of a locomotive firebox. Short patch-bolt taps are slightly tapered, in order to make a steam-tight joint.

Drills.

The High Speed Drill Company, of Dubuque, Iowa, are putting a flat drill on the market. These drills are made of a fine grade of high-speed steel, carefully tempered under the latest improved process of handling high-speed steel. The boiler makers and structural steel men will readily see the advantage of using a drill made of high-speed steel for horizontal and overhead drilling. While they do better work with oil, there is no danger of burning them if oil is not used. In a test which was made in drilling spring steel, the carbon drill would not drill one hole without being ground several times. The flat drill, made of high-speed steel, when put into use, drilled over forty holes without being sharpened and was still in good working condition. For air-drill work they are excellent, as the drill will stand the fast speed of the machine without burning the steel. The flat drill in going through a hole does not hog, but leaves a good, clean hole with very little burr, if any, at the bottom. They are easy to grind, but for the men working on outside jobs, a drill will often be used continuously for a day without requiring grinding. It is claimed that on one occasion a boiler maker countersunk over 1,000 11/16 holes with an air drill without regrinding, and the drill was apparently good for as many more.



HIGH-SPEED DRILL.

Pneumatic Drills.

The Independent Pneumatic Tool Company, of Chicago and New York, has just brought out another close-quarter piston air drill, the dimensions of which are as follows:

A, distance from throttle connection to outside of spindle case, 15⅜ inches.

B, distance from point of feed screw to end of socket, 8⅞ inches.

C, radius from center of feed screw to outside of case, 1 9/32 inches.

D, width of case at cylinder flanges, 5 3/16 inches.

G, width of case at spindle, 6¼ inches.

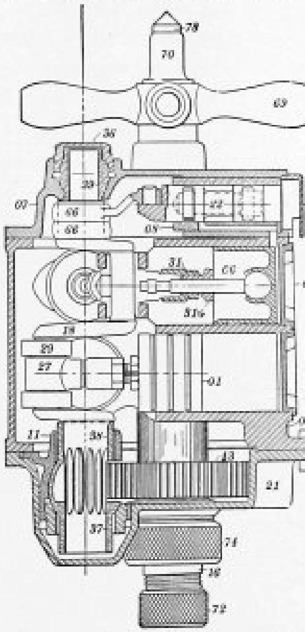
Weight, 31 pounds.

Speed, 122 revolutions per minute.

Capacity, drilling up to 3 inches in diameter, reaming and tapping up to 2 inches in diameter.

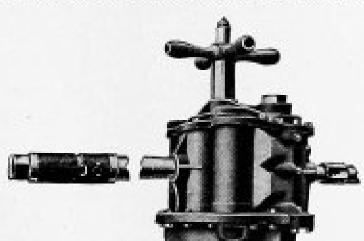
The spindle is at one extreme end of the tool and the motor at the opposite end. The motor consists of two cylinders parallel with each other, and at right angles to the spindle. The center line of both cylinders centers on center of spindle. The pistons are double acting and operate on a two-throw crank. Between the crank throws at the center are located the eccentrics, cranks and eccentrics being one forging. The eccentric straps operate directly on balanced cylindrical piston valves, having a reciprocating motion. The air is taken in centrally between the cylinders, and the valves control the air as close to the cylinder bore as material will permit. Geared to the crank shaft proper is another two-throw crank, diametrically opposed. This crank operates direct on two oscillating levers, centered on the drill spindle proper and having their bearings around the same. These levers are provided with pawls of practically the whole thickness of the lever. The pawls operate on ratchet teeth sunk in the spindle, the outer circumference, or point of teeth, leaving ample stock for bearings of the levers. The lever operating crank is arranged to have its power stroke on the part of the revolution farthest away from spindle. It therefore makes the speed of lever more uniform, pulls forward considerably more than its half revolution and returns quickly to action. The cranks being opposed, the motion of the drill spindle is continuous, with only slight variation. The engine crank proper is not on the usual 90-degree angle, but has an angle of 135 degrees, thus allowing two pistons to pull when the position of levers requires the greatest power. This makes the drill, in a degree, self-regulating, and tends to still further govern the speed of the entire revolution of drill spindle. This drill is provided with the reversible ratchet-feed mechanism, operated within the width of the body of the drill itself. A poppet valve throttle controls the speed and power, and also acts as a handle.

All "Little Giant" drills and Reversible machines manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill., are of the "balanced" piston type and consist of four single-acting cylinders arranged in pairs, each pair of pistons being



LITTLE GIANT NO. 2.—CHICAGO PNEUMATIC TOOL CO.

connected to opposite wrists of a double crankshaft; each piston of each pair travels in opposite directions at all parts of the stroke, thereby insuring a smooth-running machine. The balanced piston valves are set to cut off at 5/8 of the stroke to insure economy in the use of air without sacrificing speed or power. The feed sleeve is of large diameter and the feed liberal. The bonnet is reinforced with ribs, and a raised boss now surrounds the feed sleeve, making a substantial form of



CORLISS TYPE DRILL.—CHICAGO PNEUMATIC TOOL CO.

construction. The piston is made with rod pressed into place to eliminate troubles experienced in the past owing to the piston becoming detached from the crank, and as a further safeguard against this, the piston rods are furnished with clamp nut, serving a two-fold purpose; acting as a lock nut on the toggle, and as it clamps the piston rod at a point about half way between its length, it materially stiffens the rod, contributing greatly to its strength, yet the construction as a whole is lighter, which greatly reduces the wear on these parts, due to their reciprocating motion. The lower crank bearings are made in one piece to insure alignment, easy motion and durability, as well as to facilitate assembling. The ball face taking the end thrust on the drill spindle has been increased and larger balls are used. The total weight of the drill has not been increased. At the same time it is claimed that its efficiency (owing to better alignment and slightly increased port area) has been raised approximately 10 percent.

The thrust or strain in drilling is not borne by the main frame of the machine, but is passed directly from the drill to the feed screw by means of a spindle bearing in a fixed post upon which the feed screw is mounted. One handle contains the throttle valve and air-hose connection by which the supply of air and the speed of the machine are regulated and controlled. As the working parts operate in oil or grease, a perfect lubrication is insured at all times. This feature is unique with the Little Giant drills.

A drill the same size as the No. 2 Little Giant has also been placed on the market provided with a Corliss valve. This drill has no removable cylinder heads, and the drill is assembled through the crank case, which is split vertically and fastened with cap screws. There is but one eccentric, which is forged solid on the crank, and the valves are cast iron, operating in bronze bushings. The valve is driven by a tongue and groove in the head, the same as in a Corliss steam engine.

These drills can be furnished with two gear reductions, giving a spindle speed of either 480 or 260 revolutions. Their length over all, feed screw run down, is 14½ inches; length of feed, 4 inches; distance from center of spindle to outside of housing, 3¾ inches; spindle speed, when running light, 80 to 100 pounds air pressure, 400 revolutions per minute. They are adapted to the use of high-speed steel.

The "Cleveland" drills, manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, while essentially similar to other piston drills in their action, have several unique features. The cylinder body is in one piece with handhole openings in the crank case. These openings give immediate access to the crank connections and other vital parts of the mechanism. The valve is of the duplex rotating type in one piece and gives equal distribution of air to all cylinders. In the non-reversible drills the valve consists of one piece, while in the reversible drills it consists of two pieces. These drills exhaust to the outside, thus affording an opportunity, as in the "Little Giant" drill, of maintaining a sufficient quantity of oil in the interior of the case to insure proper lubrication. The pistons are connected by means of a ball and socket joint, in order to reduce to a minimum the chances of the pistons binding in the cylinder.

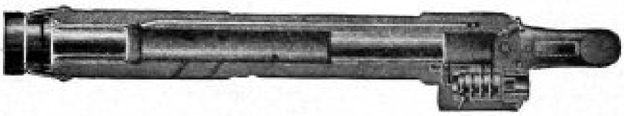
Pneumatic Riveting Hammers.

The shortness of over-all length of the "Boyer" riveting hammer, manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill., makes this tool especially adaptable for work in short space. This is a result of the construction of the valve, which is distinct from all other types, and is so constructed that the piston may pass entirely through it. It will, of course, be readily seen that from such a construction a hammer of this type can be made 1 or 2 inches shorter in over-all length, and yet maintain the length of piston stroke obtained in hammers of other types of the same capacity.

The riveting hammers manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, are operated by means of a solid valve, located in the usual valve box, covered by a cap, and the whole placed on the end of the cylinder and secured in place by the handle, which is screwed and clamped to the cylinder. The valve operates in the same plane as the piston, cushioning the piston on the return stroke so as to prevent vibration when in operation. The air is delivered through the upper back end of the grasping portion of the handle, passes entirely through the handle, and is applied directly on top of the valve. These hammers are made in styles with inside and outside latch or trigger.

The Thor pneumatic, long-stroke riveting hammer, manufactured by the Independent Pneumatic Tool Company, of New York and Chicago, is made of one solid piece of drop forging. There is no coupling between barrel and handle, and consequently no complicated lock nuts, clamps, or other delicate mechanism to get out of order and cause trouble. Another radical and valuable departure in this hammer is the placing of the valve on one side of the barrel, allowing the piston to overlap the valve in its upward stroke.

Another important feature is the auxiliary valve, designed to overcome the shock generally caused by the reversing of the piston too suddenly at end of return stroke. In this case the piston on its return opens the small auxiliary valve by



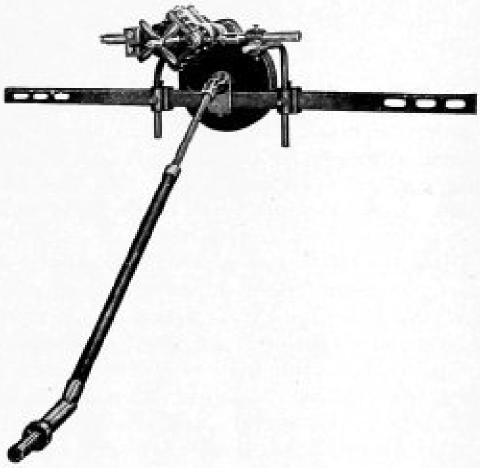
THOR HAMMER.—INDEPENDENT PNEUMATIC TOOL CO.

cushion. The piston is thus first retarded by cushion; secondly, started on its downward stroke for a short distance by a comparatively small amount of air from the auxiliary valve. Later it passes the main inlet from the valve proper, and thus obtains the highest possible speed and snappiness in its downward stroke.

The hammer has an inside safety trigger. When not in use this trigger will fall away from handle by its own weight when hammer is picked up, the workman then having his fingers between the hammer handle and the trigger. The hammer can therefore never be discharged in carrying or in waiting for a rivet. As the trigger is short it is not necessary to release the entire grip of a handle when again getting in position to operate hammer. This construction leaves the outside of the handle perfectly smooth, so that the workman has a large area of smooth surface on which to exert a pressure on the handle in riveting. The hammer is built in several sizes for driving rivets up to 1¼ inches in diameter.

Flue Cutters.

The flue cutter shown in the illustration is manufactured by the J. Faessler Manufacturing Company, Moberly, Mo. The illustration shows how it may be applied to the front end of the locomotive. The supporting bar is held in place by



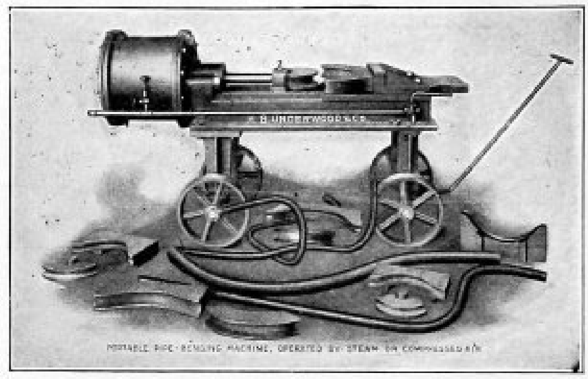
FLUE CUTTER.—J. FAESSLER MFG. CO.

stud bolts, and the motor connected to the cutter by a telescopic shaft with universal joints. This cutter has a single knife. Other forms of flue cutters, such as the O'Neil, handled by J. T. Ryerson & Son, Chicago, have wheel knives placed on carriages directly opposite each other. The carriages are then forced out by means of a wedge-shaped spindle, the cutter and spindle being turned at the same time.

A Portable Pipe-Bending Machine.

This can be driven by steam or compressed air, at 80 to 100 pounds pressure, and will bend iron pipe, cold, up to 2 inches in diameter without filling, flattening or splitting the pipe. It is also claimed that right-angle bends can be made in 2-inch pipe in two minutes or less, thus efficiently doing the work almost as rapidly as the pipe can be fed to the dies.

The piston is forced back on the return stroke by a spiral spring, projecting into a round boss of the cylinder head; the front head and piston rod requiring no packing. The end of the piston rod is supported in a crosshead, which slides in the guides. Six dies are furnished, and include sizes from ½ inch to 2 inches. The dies are easily and quickly changed, the



PORTABLE PIPE-BENDING MACHINE, OPERATED BY STEAM OR COMPRESSED AIR.

female die being centered by a dowel in the angle plate, which is adjustable along the bed-plate, bolted in place, centered and supported against the thrust of the air piston by large dowel pins. The male die is centered and supported on the end of the piston rod, which projects through the crosshead.

The truck shown in the illustration is an extra addition, and it is one which has proved so useful as to be almost an essential convenience.

This machine was designed especially by H. B. Underwood & Company, 1025 Hamilton street, Philadelphia, Pa., for general use wherever it becomes necessary to bend pipe.

Electrical Portable Tools in Boiler Shops.

The introduction of compressed air tools ten or twelve years ago in the boiler shops of the country revolutionized the manufacturing processes and has paved the way for the portable electric drill now thoroughly successful on this class of work. As many of our readers may not be familiar with the more recent developments in the line of electrical tools as applied to boiler-shop practice, we are glad to be able to present

DUNTLEY ELECTRIC DRILL.—CHICAGO PNEUMATIC TOOL CO.

cuts and a brief description of the uses of the Duntley electric tools.

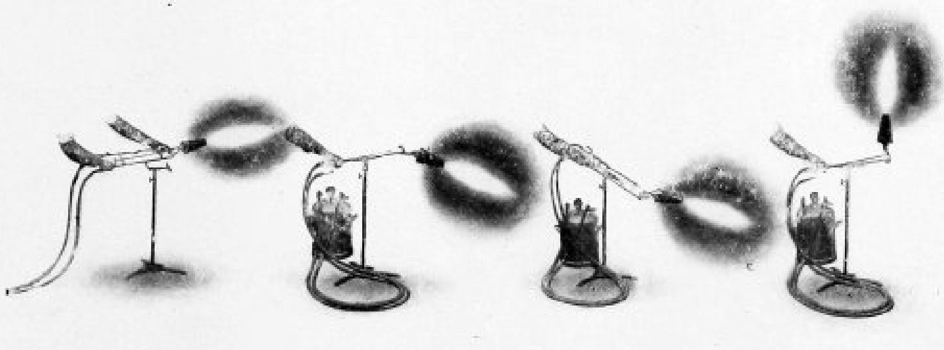
Perhaps the most severe of all boiler-shop work to be accomplished by portable tools is the rolling of flues. The cut shows the Duntley two-motor drill, especially designed for this class of work. The main switch is located at the end of one of the pipe handles and is operated exactly as is the valve on a pneumatic drill. The reversing switch is located at the left of the spade handle and can be used to control the starting as well as the reversing of the drill.

For stay-bolt tapping, as well as for reaming for rivets, a similar drill is used. A feed screw can be substituted for the spade handle where drilling is to be done. Frequently these tools are applied to reaming on structural steel work.

One very common application of the electric drill is to the drilling of tell-tale holes in stay-bolts. These holes, about 3/16 inch in diameter, may be drilled by means of the Duntley breast drill, weighing but 13 pounds.

Portable Heaters.

A patented improvement on oil heaters for boiler shops has recently been developed by the Hauck Manufacturing Company, Richards Street, Brooklyn. The illustration shows a few of the positions into which the burner can be changed instantly while in operation, making it possible to go into the closest space without any difficulty. These burners are made in two styles. One is operated in conjunction with compressed air, using crude fuel or kerosene oil. The other is self-contained, in which the oil is evaporized and burns kerosene or coal oil. The degree of heat and the direction of the flame may be regulated instantly without removing the burner itself. These burners can also be used in connection with a patented stand, which interlocks the burner without screws and without delay.



VARIOUS POSITIONS OF PORTABLE HEATER.—HAUCK MFG. CO.

HAUCK PORTABLE HEATER.

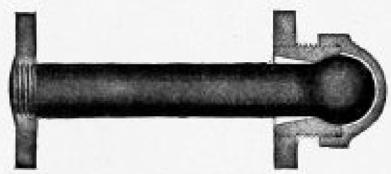
The Perambur workshops of the Madras Railway will shortly be driven electrically, the installation including four sets of Diesel engines, the plant generating about 1,500 kilowatts. Electric motive power is also being introduced into the Negapatam shops of the South Indian Railway, in this case steam sets being used.

Supplies.

Staybolts.

Widespread trouble, due to the breakage of ordinary rigid stay-bolts, has led to the development of different types of flexible stay-bolts. Flexible stays do not resist the variation in expansion between the inside and outside sheets so that the excessive bending stresses caused in rigid stays due to this action are not set up in flexible stays.

The Tate flexible stay-bolt, manufactured by the Flannery Bolt Company, Pittsburg, Pa., which is widely used in locomotive boilers, is of the round-head type. The head has a spherical bearing on a separate sleeve, which is screwed into the outside sheet. The sleeve has a flaring mouth at the water-space end, and a machine-made surface on the outer end for the cap bearing. The cap itself is of drop-forged steel, carefully machined to seat itself on the sleeve bearing and make a steam-tight joint without the use of a gasket. A clearance is left between the bolt head and seat, so that the bolt may free itself from incrustation and have an opportunity for longitudinal expansion. The only machine work done on the surface of the bolt is to cut the threads at the fire-sheet end where it is screwed into the fire sheet and riveted over.



TATE FLEXIBLE STAY-BOLT.

Other flexible stays have been developed on the eye-bolt principle. The ordinary rigid bolt is also frequently replaced by a hollow stay, for it is claimed that sufficient oxygen is admitted through the small 1/8 or 3/16-inch hole in the hollow stay-bolt to equip a modern high-pressure locomotive boiler to carry out almost perfect combustion of the fuel. Also the current of air passing through the hollow bolt reduces its temperature, thereby preventing undue expansion and contraction.

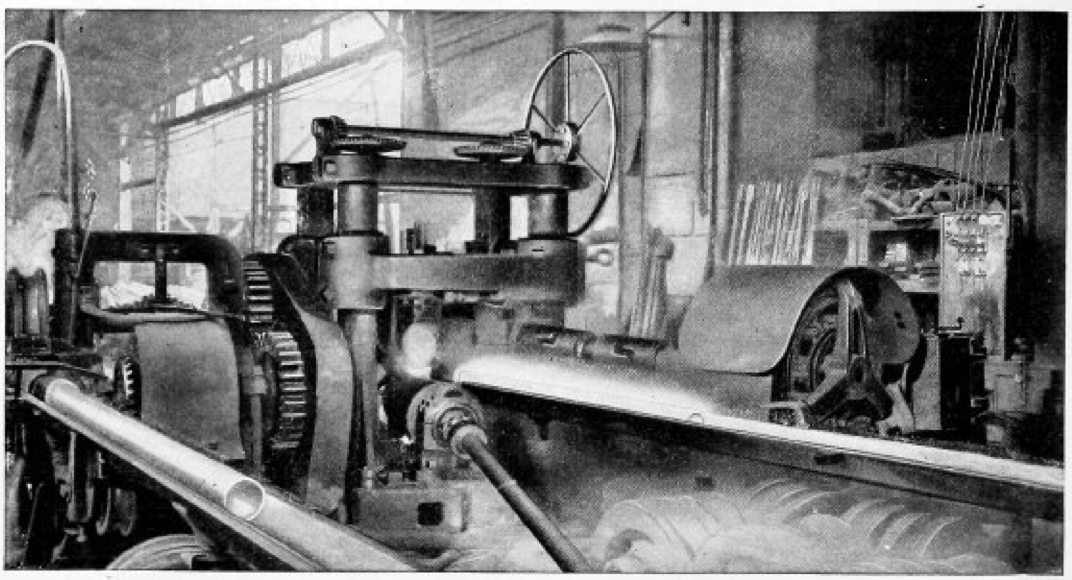
The air thus acts as a protection against the burning of the inner ends of the stays and the cracking of the side sheets. The Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, manufacture hollow stay-bolt iron for this purpose of high grade, double refined charcoal iron, which is a blend of imported Swedish and native high-grade charcoal iron stock.

Tubes.

There are three principal kinds of boiler tubes in use—cold-drawn steel, lap-welded steel and lap-welded charcoal iron.

Cold-drawn steel tubes are made from a solid round billet; the billet is pierced to form a hollow tube with a thick wall, which is subsequently rolled down to a smaller size, thinning out the steel, after which it is cold drawn to the required size or gage. The piercing operation is performed by passing the billet through two disks, one placed slightly above the other, and rotating in opposite directions. The disks are so arranged that the sides form a tapering, narrow pass. The disks give to the billet a rotary and slightly forward motion, forcing it over a stationary, pointed mandrel, which is placed midway in the pass; thus a cylindrical hole is formed throughout the entire length of the billet. After reducing the hollow tube by passing it through suitable rolls and over different sized mandrels, balls or plugs, the tube is ready for the cold-drawing process. This consists of heavily coating the tube with oil or some lubricant, after which it is pulled through a circular die, and at the same time over an inside-supporting mandrel, the die forming the outside diameter and the mandrel the inside. The number of passes necessary depends upon the size and gage of the tube.

Lap-welded tube is manufactured in two operations—bending and welding. The plate is first beveled on the edges and then passes through a bending machine, where it takes roughly the cylindrical shape of pipe with the two edges overlapping; it is then re-heated and passed through the welding rolls, each of which has a semi-circular groove corresponding to the size of the tube being made. A cast-iron ball or mandrel, held in position between the welding rolls, serves to support the inside of the pipe as it is welded. The illustration shows lap-welded boiler tubes passing through the sizing and crossrolls at the plant of the National Tube Company, Pittsburg, Pa.



TUBES PASSING THROUGH SIZING AND CROSS-ROLLS.—NATIONAL TUBE CO.

STANDARD CHARCOAL IRON AND STEEL LAP-WELDED BOILER TUBES.

Published by the Parkesburg Iron Company, Parkesburg, Pa.

Outside Diameter.	Thickness, Inches.	Thickness Nearest B. W. G.	Nominal Weight Per Foot.
1 inch	.095	13	.90
1¼ inches	.095	13	1.15
1½ inches	.095	13	1.40
1¾ inches	.095	13	1.66
2 inches	.095	13	1.91
2¼ inches	.095	13	2.16
2½ inches	.109	12	2.75
2¾ inches	.109	12	3.04
3 inches	.109	12	3.33
3¼ inches	.120	11	3.96
3½ inches	.120	11	4.28
3¾ inches	.120	11	4.60
4 inches	.134	10	5.47
4½ inches	.134	10	6.17
5 inches	.148	9	7.58
6 inches	.165	8	10.16
7 inches	.165	8	11.90
8 inches	.165	8	13.65
9 inches	.180	7	16.76
10 inches	.203	6	21.00

Furnaces.

The Morison corrugated suspension furnace, manufactured by the Continental Iron Works, Brooklyn, N. Y., forms a very important feature or part of Scotch marine, as well as internal furnace, boilers for stationary service. The accordion-like action of this furnace not only relieves the tubes and tube heads from undue strains, resulting from expansion and contraction, but breaks the scale loose, and same is dislodged by the circulation of steam bubbles in their upward passage, thus scouring the furnace walls and tubes. The Morison corrugated furnace contains slightly increased heating surface, and is approximately four times stronger against collapse than a plain furnace of same thickness.

In the construction of a plain furnace or an Adamson ring furnace, the metal must be of such a thickness to withstand the required steam pressure, that heat is not readily imparted

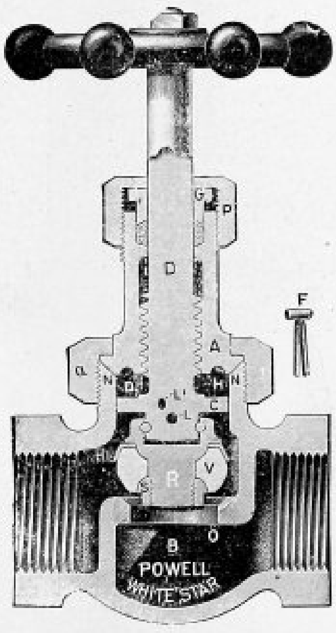
MORRISON CORRUGATED FURNACE.

to the water through same, and where bad feed water is used, scale forms readily on the smooth surface or exterior of the furnace, thus insulating it and destroying the heating surface to a marked degree, and the efficiency correspondingly; besides, there is the liability to "bag," as in the crown sheets of the horizontal return tubular boiler, by keeping the water from the sheet or wall of the furnace. The Adamson joint, commonly used in the Adamson ring furnace, consists of sections of tubes with flanged ends riveted together, with a calking ring interposed. Wherever this joint appears there are three thicknesses of metal. The number of these joints in each furnace increases the possibility of leakage, and the repair bills accordingly.

All of the expansion and contraction must be taken care of on the tube heads or in the flanged joint. If in the former, the life of the tubes must necessarily be short; if in the latter, the flange of the joint crystallizes, causing cracks, repeated patching, to say nothing of leaks in these joints when starting fire. Marine boilers must of necessity use corrugated furnaces, owing to the stringent inspection laws of the United States Government, which would call for Adamson or plain furnaces to be of such a thickness to withstand the steam pressure, as to destroy all of the valuable features of the Scotch marine type of boiler.

Valves.

To-day a valve must be capable of withstanding the higher pressures and also the wearing forces contained in superheated steam, and be absolutely reliable at all times. The Powell White Star Valve, manufactured by the William Powell

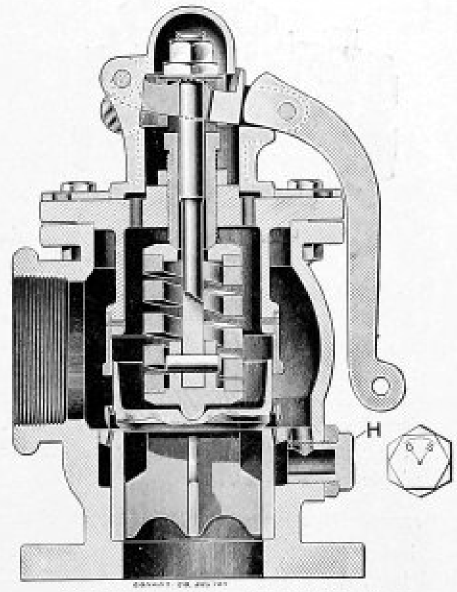


WHITE STAR VALVE.

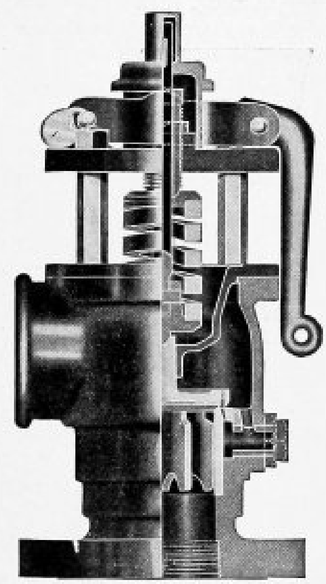
Company, of Cincinnati, Ohio, gets its name from the peculiar silver white disc used for disc and seat. The metal used for this purpose (Powellium White Bronze) is, it is claimed, of a composition that has unusual wearing qualities, and having a melting point of high temperature (2,000 degrees F.). The bonnet is coned and ground to a bearing to fit the body neck and secured thereto by a union nut, which makes, it is claimed, an absolutely tight joint. The manufacturers state that owing to the expanding thread of the beveled face of the bonnet upon the neck of the body shell the tighter the coupling nut is wrenched down, the greater is the expansion of the metal, making it impossible to blow off the top rigging under heavy pressure.

The discs have duplicate wearing faces and are screwed to the revolving carrier and protected by a flange on the upper and inside faces until the lower face is worn out. They may then be reversed and the valve is ready for new life. The disc is attached to the holder by a jam nut, which holder swivels on the stem and is covered with a flange to protect the upper face of the disc from scale or corrosion while the lower face is in service. The stem is centrally guided within the neck of the body by wing guides. The valve stem is pierced to receive a lock bar when locking the disc for grinding.

The old style of lever safety valve is practically a thing of the past, and it has been superseded by spring pop valves of the type shown in the illustration. This illustration shows the Ashton improved lock-up pop safety valve, manufactured by the Ashton Valve Company, Boston, Mass. It has a high-



POP SAFETY VALVE.—ASHTON VALVE CO.

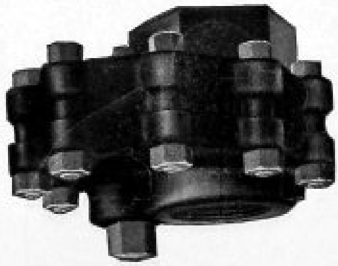


SAFETY VALVE FOR SUPERHEATED STEAM.

grade composition nickel seat, beveled at an angle of 45 degrees. The valve is double guided above and below the seat, and has a knife-edge pop-chamber lip. The spring of Jessop's steel is encased, and the spring disks are pivoted. Both the inlet and outlet connections are on the base casting. The valve combines a lock-up attachment and outside pop regulator.

The use of superheated steam has made it necessary to build valves of special types to withstand the high temperature obtained with superheated steam. The valve designed for use with superheated steam, which is shown in the illustration, is manufactured by the Ashton Valve Company, Boston, Mass. It has a cast-steel body and is fitted with a solid nickel-seat bushing and wing valve. The spring is of Jessop steel and is located outside the valve body, so that the steam does not come in contact with it. The lifting attachment is a compound lever which can easily be raised by hand, and the pressure adjustment has a lock-up attachment to prevent tampering.

Blow-off valves are manufactured in many different types, the details of no two of which are alike. The "Everlasting"



EVERLASTING BLOW-OFF VALVE.

blow-off valve, shown in the illustration, handled by the Scully Steel & Iron Company, of Chicago, is designed for a pressure of 250 pounds. The opening through the valve is a straight passage, and it is claimed that the valve is perfectly self-grinding and self-compensating. A special type is manufactured, designed to meet the needs of railroad service, and differs from the valve used in stationary or marine service only in its nipple connections.

Lugs, Braces, Pipe Flanges and Manhole Covers.

Cast-iron boiler lugs have been largely superseded by pressed-steel lugs, since they can be riveted to the shell and can be formed of such section as to best resist the strains induced. In the Roe boiler lug, shown in the illustration, which is manufactured by the Glasgow Iron Company, Pottstown,

ROE BOILER LUG.

Pa., the upper or compression member is corrugated for strength, while the bottom member is flanged on the sides to give stiffness as a girder and is flat to admit the use of rollers.

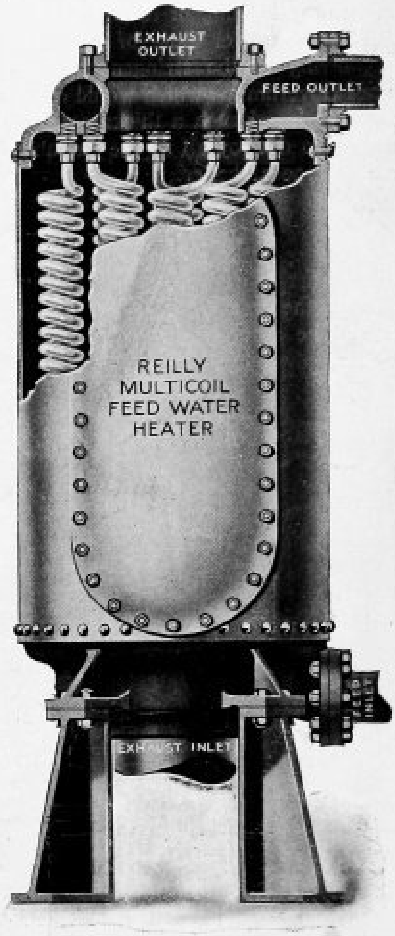
Various types of manhole covers and yokes are manufactured, which are designed to give an absolutely tight joint. The "Roe" manhead, shown in the illustration, is a true

ROE MANHOLE COVER.

ellipse, and the metal is disposed in a series of corrugations, the central corrugation forming a dovetail, which grasps a bolt. In the saddle yokes, the base of the yoke is concave and rests on the saddle instead of on the shell of the plate, thus relieving the shell of any unnecessary strain.

Feed-Water Heaters.

It is repeating an old story, well known by every engineer and boiler maker, to say that the injection of cold feed water into a boiler, particularly into a cylindrical fire-tube boiler, causes serious and dangerous local strains, and ultimately gives rise to leakages, and wear and tear, for which the boiler maker is



REILLY FEED WATER HEATER.

frequently blamed unjustly. The increased capacity and efficiency of a boiler resulting from feeding it with water already heated to 210 degrees or so, is immensely important.

It is true that while most engineers understand this qualitatively, few are able to say just how much the capacity of the boiler would be increased, and how much its efficiency, as the result of a proper feed-water heater. They know only in a general way that it is true, but when it comes to figuring out whether it is better to put in a feed-water heater, or leave it out, they cannot figure the matter out in dollars and cents.

The Griscom-Spencer Company, 90 West street, New York City, engineers and manufacturers of the Reilly multicoil feed-water heater, have recently gotten out a new catalog entitled "Facts and Figures about Feed-water Heating." In the first part of this catalog they have given readers the benefit of the results of extended experiments they have made in perfecting the heater that they manufacture. There are several tables given to facilitate easy computation of the actual cash value of hot water fed to the boilers, and also an explanation is given of the method of figuring this saving in a specific case without the use of the tables.

Many boiler makers appreciate the truth of the above, and some realize that it is of sufficient importance to instruct their salesmen to interest customers in feed-water heaters at the same time as boilers, since in many cases the use of a feed-water heater will increase their boiler capacity by 16 percent.

THE BOILER MAKER

VOL. VIII JULY, 1908 No. 7

LAYOUT AND CONSTRUCTION OF A LARGE WATER TANK.

Recently bids were asked by the Louisville (Ky.) Water Works Company for a standpipe 50 feet in diameter and 220 feet high. The Chicago Bridge & Iron Works, Chicago, Ill., figured on this job, finding that for a standpipe of these dimensions the metal at the base of the pipe would have to be about 2.4 inches thick, a construction which would require two cannot be used unless it is desired to store the water at a considerable elevation. Water stored for use would preferably be without change of pressure. As long as this is impracticable varying pressures of from 5 to 10 pounds per square inch are accepted, making a condition which is easily fulfilled by the design mentioned above.

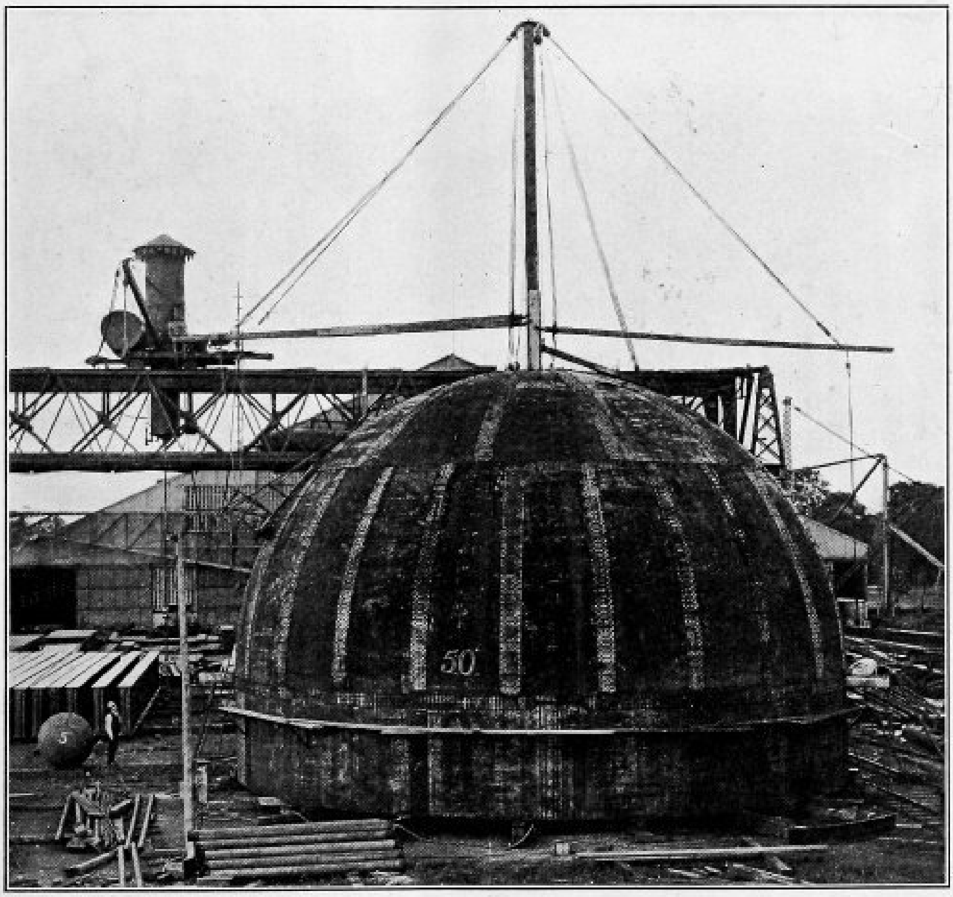


FIG. I.—HEMISPHERICAL BOTTOM ASSEMBLED AT BUILDER'S YARD FOR REAMING.

thicknesses of plate making a design which is entirely without precedent. Upon inquiry by Mr. Charles Hermany, engineer, it was learned that only the water in the upper section of this standpipe was wanted for service, and so the design of the tower and tank illustrated in this article was substituted for the standpipe. It may be asserted that the tower and tank is applicable for conditions beyond the practical scope of the standpipe. Such will always be the case when any considerable height is required in connection with a large volume of water. When the height becomes at all extreme the standpipe design will not be used. On the other hand, a tower

When water is wanted at an elevation of 50 feet or less it is entirely a matter of personal choice whether it shall be stored in an elevated tank or standpipe. If, however, it is wanted at an average elevation of 100 feet, it will cost twice as much to store it in the stand pipe as in an elevated tank. Should the water be wanted at an average elevation of 150 feet, it will cost three times as much to store it in a standpipe as in an elevated tank. Similarly, at an elevation of 200 feet it will cost four times as much to use the standpipe as the tower and tank. At 250 feet the standpipe will cost five times as much as the tower and tank, and at 300 feet six times as much. From this it is easily seen why towers and tanks have come into general use for storage of water where its potential energy is a matter of consideration.

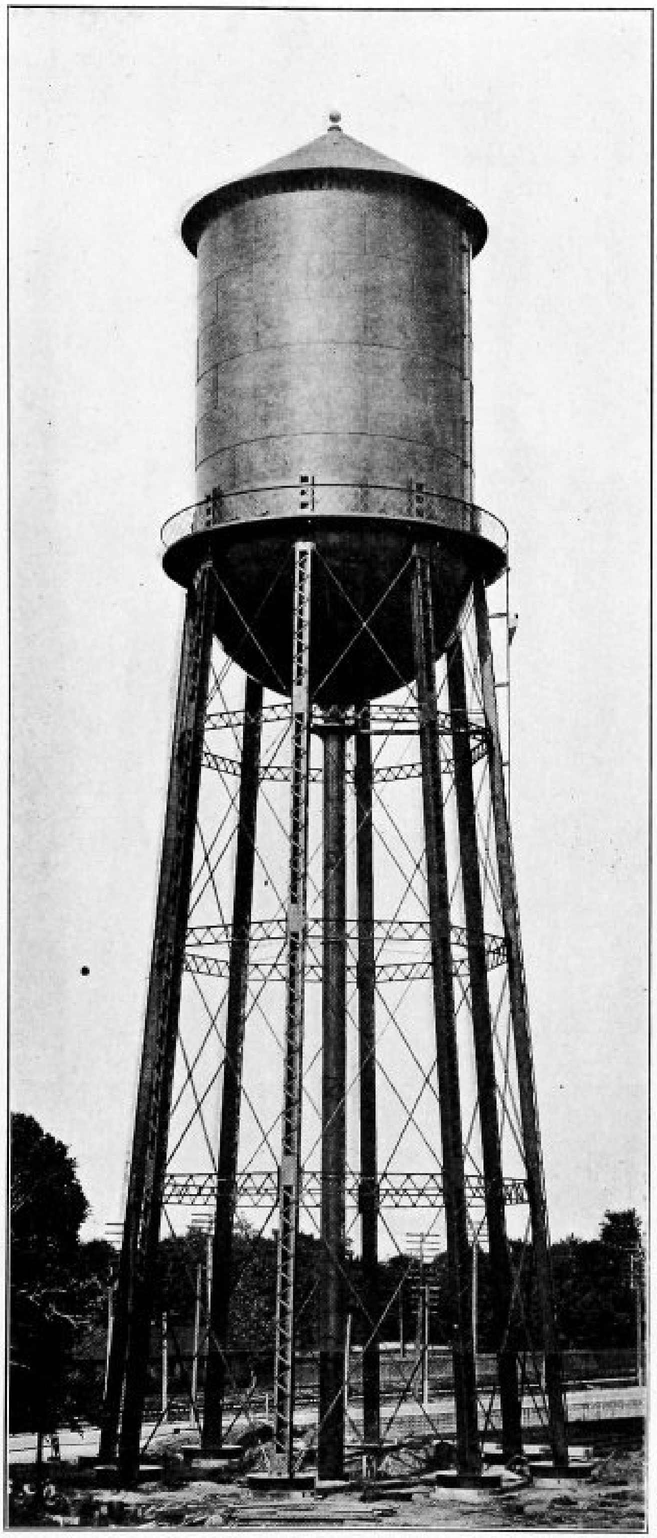


FIG. 2.—THE COMPLETED TOWER AND TANK.

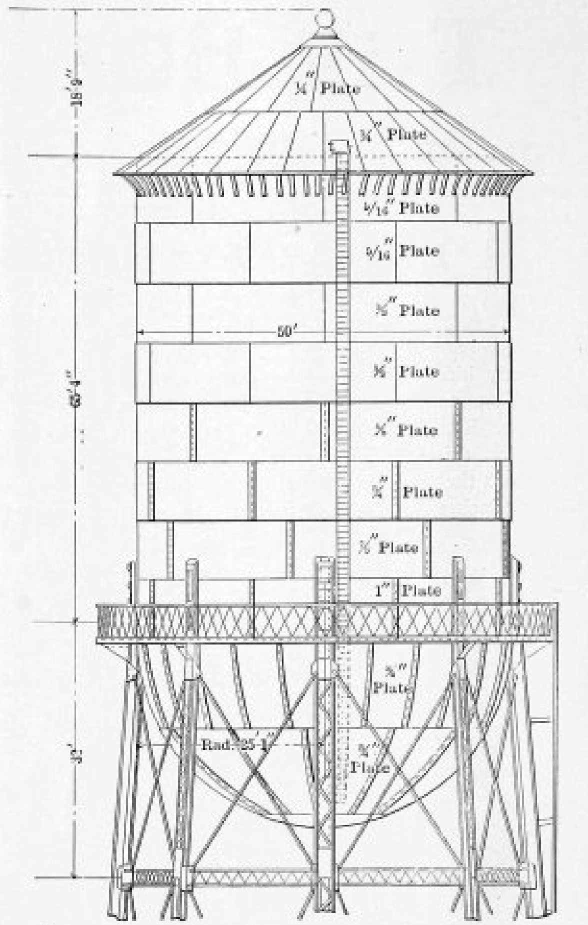


FIG. 3.—OUTLINE OF THE TANK SHOWING PRINCIPAL DIMENSIONS.

The tank which was finally designed by the Chicago Bridge & Iron Works for the Louisville Water Works Company has a capacity of 1,200,000 gallons of water, which is equal to a load of 10,000,000 pounds. It consists of a cylindrical steel tank 50 feet in diameter, 65 feet 4 inches high, with a hemispherical bottom 24 feet 11¼ inches deep, and a conical roof 18 feet 9 inches high. It is supported at a height of 155 feet by eight riveted steel columns. A vertical riveted steel pipe, 50 inches in diameter, extends from the center of the bottom of the tank to the regular water mains about 12 feet below the ground. Access is had to the tank by means of a steel ladder fastened to one of the columns, and extending to a small balcony built around the bottom of the tank; from this balcony a light ladder extends to the top of the tank, where a door in the conical roof gives access to the inside of the tank.

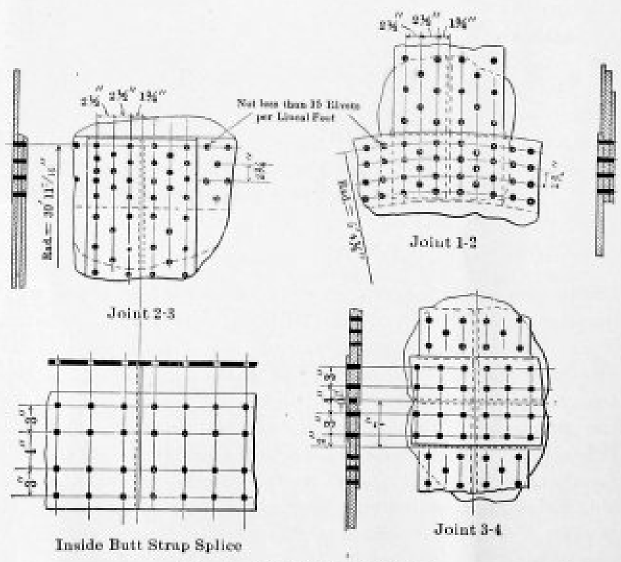


FIG. 4.—DETAILS OF RIVETING.

A second ladder extends down into the tank on the inside from this door.

The cylindrical part of the tank consists of eight horizontal courses of plates, alternate courses being inside and outside. Each course contains eight plates, each plate being about 19 feet 7¾ inches long. This length varies slightly with each course of plating, as the length of the entire course is figured from the diameter to the center of the thickness of the plate, a quantity which varies with the thickness of the material. In Fig. 5 details are shown of the layout of these plates, showing the exact length, width, rivet spacing, etc. All of the horizontal or girth seams are single riveted lap joints. The size of rivets varies from ⅞ inch at the bottom to ⅝ inch at the top; the spacing for the ⅞ rivets being about 3½ inches and for the ⅝ rivets about 2⅞ inches center to center of holes. The vertical seams in the lower course of plating are fastened by triple riveted double butt strap joints, ⅞-inch rivets being used, spaced about 3¾ inches center to center of holes. Triple riveted butt joints are used for the vertical seams in the four lower courses of plating, while in the fifth a quadruple riveted lap joint is used; in the sixth, a triple riveted lap joint, and in the seventh and eighth double riveted lap joints.

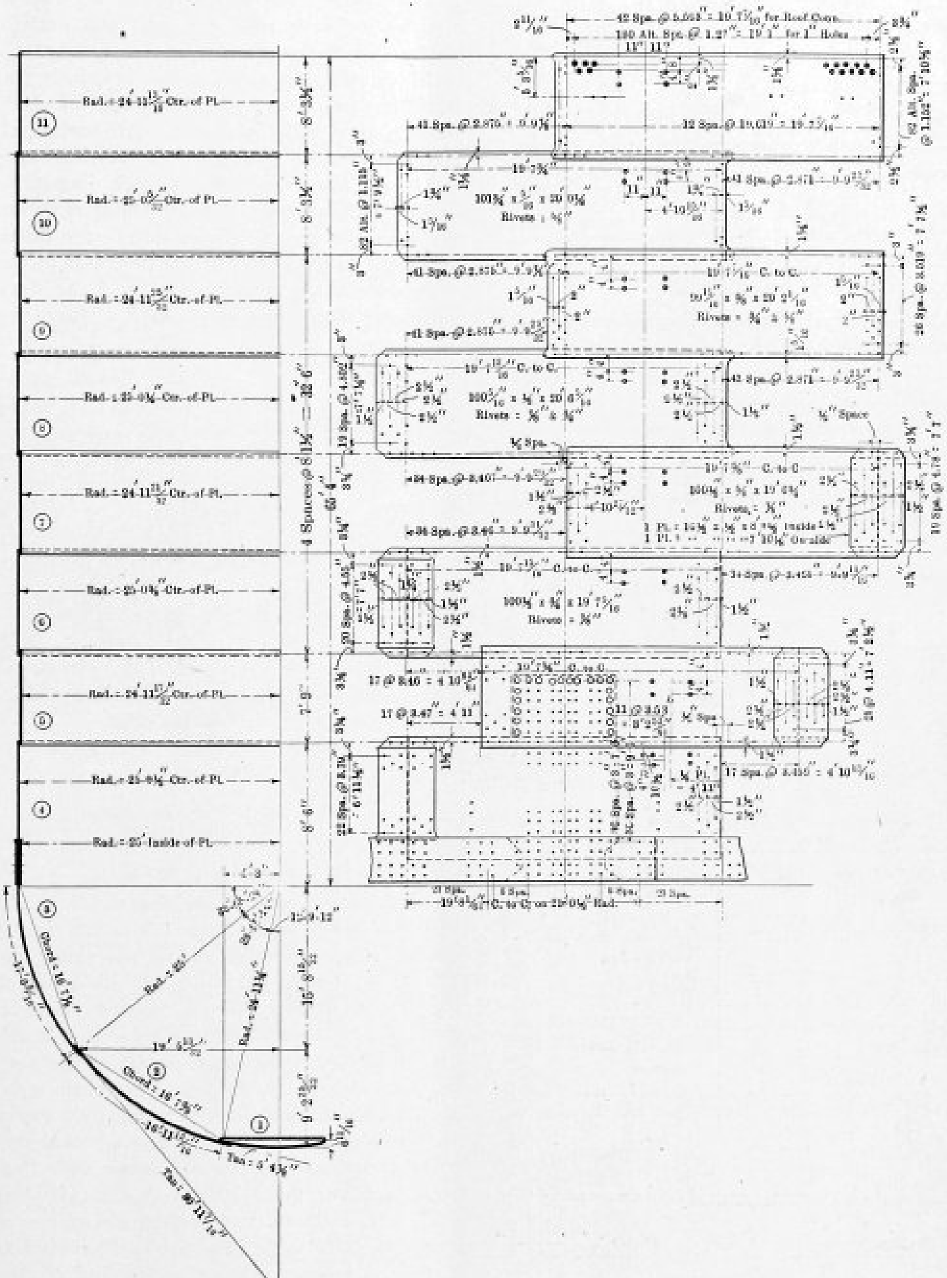


FIG. 5.—LAYOUT OF SHELL PLATES.

The thickness of the shell plates varies from 1 inch at the bottom to 5/16 inch at the top. The bottom plates are reinforced by inside and outside cover plates, 30 inches wide and ½ inch thick, riveted to the curved hemispherical bottom plates.

The hemispherical bottom is made with two courses of ¾-inch plate, fastened together with butt straps 16½ inches wide and ½ inch thick. The bottom of the tank consists of a dished plate 10 feet 9 inches in diameter and ¾ inch thick. Details of the riveting are shown in Fig. 4, the rivets all being ⅞ inch in diameter, and spaced so that there are not less than fifteen rivets per lineal foot.

The details of the method of laying out the hemispherical part of this tank are shown in Figs. 9, 10 and 11. Fig. 9 is a quarter section, showing the length of the plates measured along the arc of the circle, and also the length of the chord which each plate subtends, together with the versed sine or

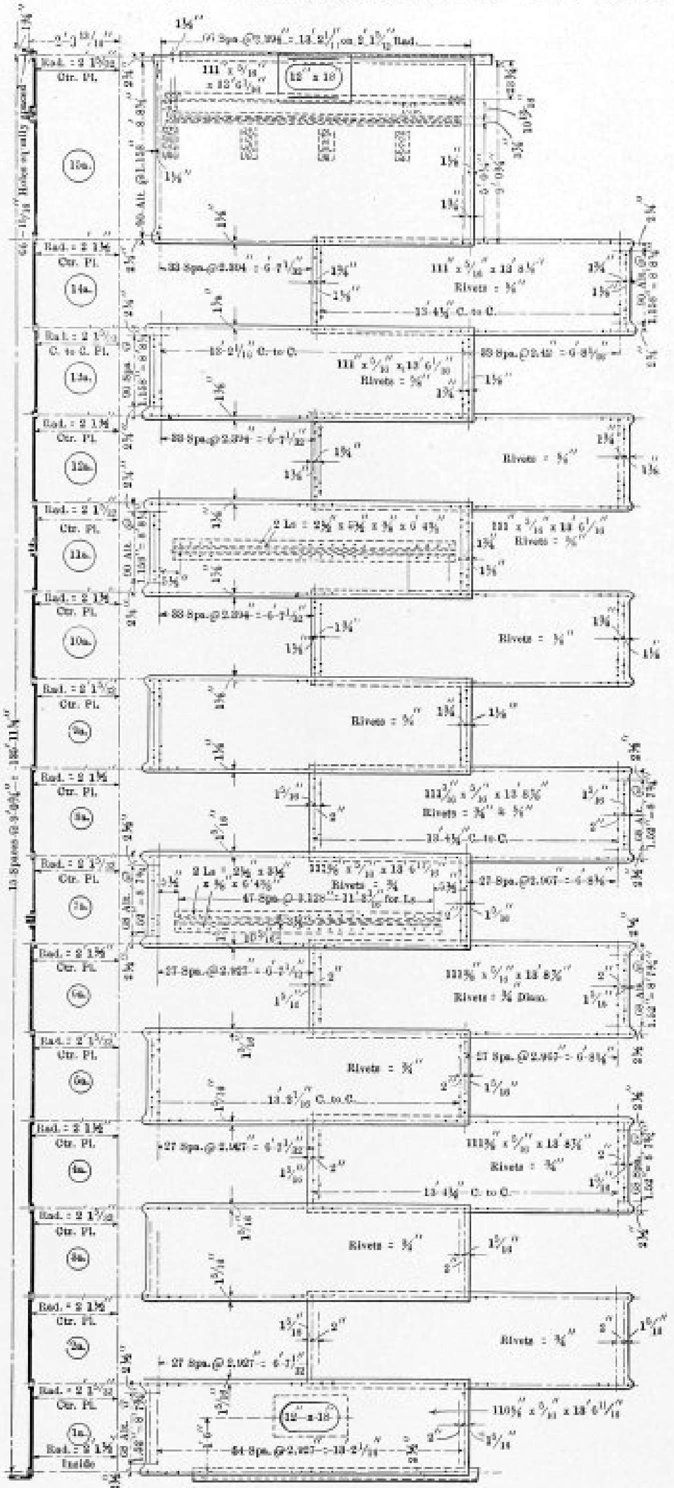


Fig. 6.—Layout of Vertical Pipe.

distance from the center of the chord to the arc. In the development, Fig. 5, the lengths of the tangents at points of intersection of the courses are also shown, as well as the magnitude of the angle which each plate subtends at the center of the tank. Knowing the radius and the chord, the length of the plate measured along the arc of the circle can be figured. The plate can then be divided into a number of equal parts, and the offset or width of the plate at each of these sections can be measured, the width in each case being a certain part of the circumference of the tank at this point. These offsets can then be laid out as shown in the patterns of Figs. 10 and 11, giving the true development of the curved plates. All these dimensions are clearly indicated on the drawings and can be readily verified by making these calculations.

The development of the plates for the vertical pipe connecting the tank with the inlet and outlet pipes below the surface of the ground, is shown in Fig. 6. This pipe is 50 inches in diameter and 135 feet 11¼ inches high, and is made of fifteen inside and outside courses of plating, the thickness of each plate being 5/16 inch. All horizontal girth seams are single riveted lap joints, and the vertical seams double riveted lap joints, the rivets being ¾-inch diameter at the top. The exact length of each of these plates is determined by finding the circumference corresponding to the diameter of the plate measured to the center of the thickness of the metal.

Details of the conical roof and the development of the plates are shown in Figs. 7 and 8. The roof consists of three

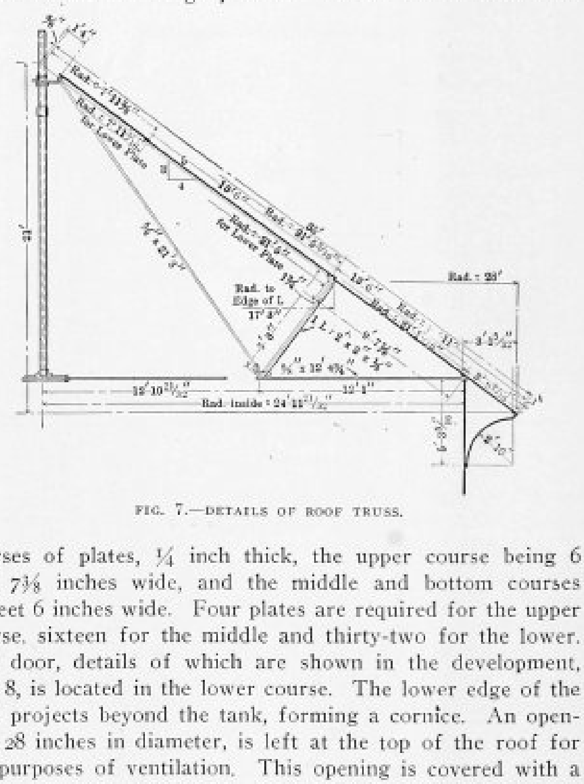


Fig. 7.—Details of Roof Truss.

courses of plates, ¼ inch thick, the upper course being 6 feet 7⅜ inches wide, and the middle and bottom courses 13 feet 6 inches wide. Four plates are required for the upper course, sixteen for the middle and thirty-two for the lower. The door, details of which are shown in the development, Fig. 8, is located in the lower course. The lower edge of the roof projects beyond the tank, forming a cornice. An opening, 28 inches in diameter, is left at the top of the roof for the purposes of ventilation. This opening is covered with a conical cap, through which a flag pole extends for a height of nearly 40 feet. The roof is supported by light, triangular trusses, consisting of sixteen screw rods fastened to a circular ring at the top of the roof and extending to the foot of angle struts normal to the roof, and riveted at the upper end to a horizontal angle fastened to the joint between the second and third courses of roof plates, and at the lower end to a circular angle about 26 feet in diameter, which is held in place by ⅝-inch horizontal radial rods, the outer ends of which pass through the upper edge of the cylindrical walls of the tank. Forty-eight similar rods extend endways from the circular angle, with their inner ends bolted between a pair of 3/16-inch spider plates, which constitute the base for the flag pole.

The hemispherical part of the tank, including the first course of cylindrical plates, was completely assembled upside down in the builder's yard before shipping, in order to ream the rivet holes. The photograph, Fig. 1, shows this part of the tank assembled in the builder's yard, and gives some idea of the immense size of the tank, as this part alone is 60 feet

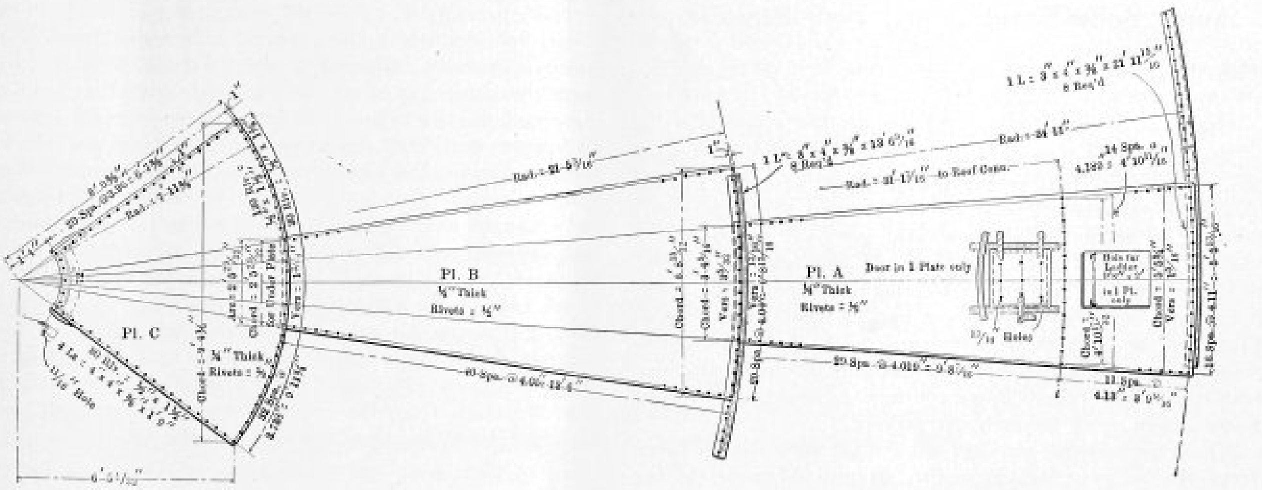


FIG. 8.—LAYOUT OF ROOF PLATES.

high and 50 feet in diameter. In the photograph it will be seen that a wooden mast, or spar, extends through the pipe opening in the bottom plate. This mast is nearly 80 feet tall, and is secured at the foot on the ground at the center of the tank, and again at the pipe connection hole, where it passes through the top of the tank. The mast is equipped with four light booms, capable of handling plates of a maximum weight of 6,500 pounds each. These booms also serve to suspend four reaming machines with their tackles. Two of these reaming machines were of special design, made by the Chicago Bridge & Iron Works, and operated by electricity; the other two were pneumatic reamers, built by the Chicago Pneumatic Tool Company. All were provided with light frames, for the purpose of maintaining the drills in a position radial to the hemispherical plates, thus insuring accurate reaming of the rivet holes. The total number of holes reamed in this way was estimated at 15 000, each being through about 2 inches of metal. Twist drills were used in place of fluted reamers.

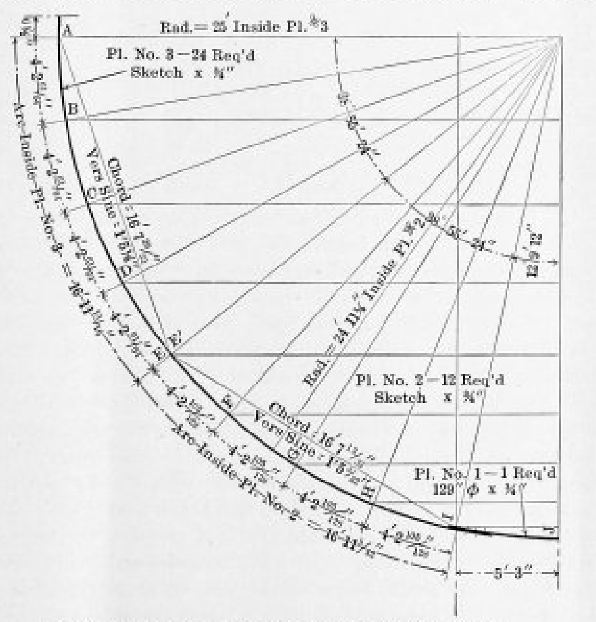


FIG. 9.—QUARTER SECTION OF HEMISPHERICAL BOTTOM.

This was the only part of the tank which was assembled at the builder's yard previous to erection, the remaining work being done in the field.

When the tank was erected, it was necessary to rig tackle capable of handling weights of 25,000 pounds, since this was the weight of each of the main posts. This was accomplished by using a gin pole 14 by 14 by 56 feet. As fast as a section of the struts was bolted in place the pole was lifted to a position at the top of the struts for the purpose of raising the next section. After the supporting columns for the tank were in place, much lighter tackle could be used, as none of the plates in the tank itself weighed over 8,000 pounds. After the hemispherical bottom of the tank was erected a temporary platform was built upon it, and a stiff-legged derrick placed there, by means of which the cylindrical tank and roof were erected.

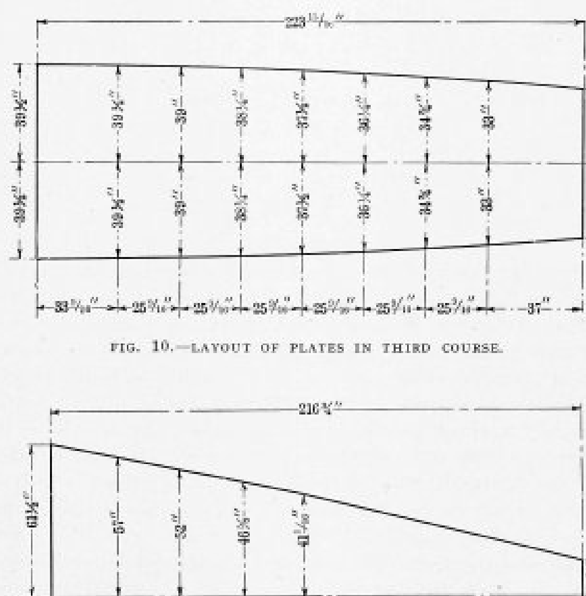


FIG. 10.—LAYOUT OF PLATES IN THIRD COURSE.

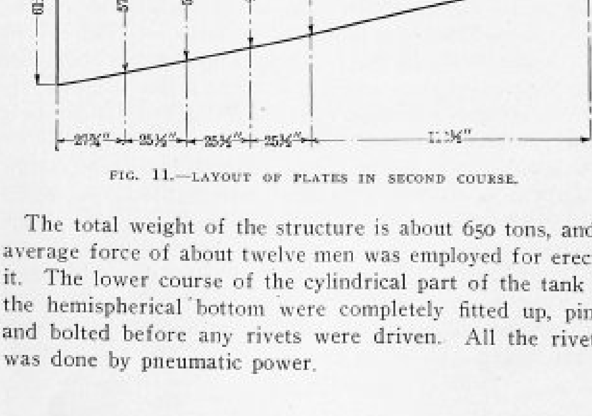


FIG. 11.—LAYOUT OF PLATES IN SECOND COURSE.

The total weight of the structure is about 650 tons, and an average force of about twelve men was employed for erecting it. The lower course of the cylindrical part of the tank and the hemispherical bottom were completely fitted up, pinned and bolted before any rivets were driven. All the riveting was done by pneumatic power.

Some Boiler Troubles and Their Remedies.

BY FRANK COLLINS.

BOILER SETTINGS.

A horizontal tubular boiler should always be set from 1 to 2 inches lower at the back than in the front, since this causes the sediment to drift to the lowest point, where it can be blown out through the blow-off. By doing this frequently, there is no doubt but what you will get good results where the scale does not adhere to the shell and tubes, but when this takes place, I know of no permanent cure except good, pure water, which is hard to get, and in many places impossible, and the older the country gets, the harder it will be to procure this. Water filters will have to be used more extensively in the future if we continue to use steam. More water filters mean fewer boiler makers.

Where flush fronts are used, do not set them too far away from the boiler. Sixteen inches, in my judgment, is far enough. Where a front is set 24 inches away from the boiler, you have too much of an arch to protect. The fireman cannot get his coal under the boiler far enough. Most of the arches are built up against the boiler to the calking edge, and at most, just over the rivet line on the head. The heat from the furnace soon burns through the arch at this point, and as soon as this takes place you have a short circuit, that is, much of the heat from the furnace, in place of traveling along the shell and back through the tubes, passes directly up the stack from this point and you have not only a loss of heat, but a damaged boiler. Most all practical men know there is a limit beyond which water will not protect the plates from the fire. The shell and head riveted together at this point are above that limit, and the heat passing over this, aggravated by a little sediment, soon causes a defect which we call fire cracking. While this is not a dangerous condition it means a little misfortune for the operator and a little prosperity for the boiler maker. The remedy for this is to be sure and keep your arches up in good shape. A center support for this arch should be provided in all front frames.

FIRE CRACKS.

When fire cracks develop in the boiler, causing bad leaks, for temporary repairs I would recommend cutting out the rivet at the crack, drilling a small, say ½ inch, hole close to the rivet hole in the crack, tapping it out and screwing a plug in place, riveting same in good shape, then cutting off the plug flush with the plate inside and outside. Next drive your rivet again and calk it carefully; then you will have a good, tight joint and one that will be no weaker than it was at first, whereas if you cut the crack away so you can drive the rivet down to the inside sheet you can make it tight, but you will weaken the plate.

Regarding the construction of the standard tubular boiler, that is, the boiler built up in three circular courses, there is no doubt but what this method adds some strength to the boiler, but is it a good way for the operator? I question the wisdom of this, and I antagonize any method that will leave a seam over the fire where the material in the boiler is about ½ inch thick. Outside of the Lake districts there are few places where they have good water, and while under ideal conditions this seam over the fire may not give the operator much trouble, in most places where they have a scale formation to contend with they are continually in trouble with this seam. It fire cracks badly, and when you resort to patching, you do not improve the condition any, as patching, as a rule, is an unsatisfactory job. I have found that by driving the rivets with an air hammer the patch will hold better than with hand riveting, the pitch of the air rivets adds strength to the seam, the rivets and calking will not spring so badly and the patch will last longer.

CLEANING TUBES.

It is bad practice to clean the tubes from the front of the boiler. The soot is blown to the back end, and the draft from the stack carries part of the waste back in the tubes; the remainder lies in the flame bed, where it soon fills up and chokes the heat from the furnace. This is not the only bad effect of blowing the soot to the back end and leaving it there, however, as the soot under certain conditions will take fire and make an intense heat. I have known it several times to bag the shell at the blow-off where a little sediment lay on the inside, in one instance bagging the plate for a length of 4 feet and ripping a hole in it 18 inches long. A high pressure of steam would have wrecked this boiler.

A remedy for this is, put a frame in the back wall and swing two doors lined with bricks something like the front doors; blow the tubes from the rear end and when through, open the front doors and drop the soot into the ash-pit.

PATCHING.

If you are unfortunate enough to bag any of your boilers over the fire, that is directly over the grate area, if you can possibly spare the boiler for a couple of weeks do not patch it; strip the boiler and put in a half sheet. The first cost is more, but in the end you are money ahead, both in the cost of repairs and the time lost in trying to keep the patch tight, which, from my experience, boiler makers have been unable to do for any length of time, where a boiler is fired heavily or where you have a little scale formation. This is referring to the up-to-date high-pressure return tubular boiler, where the plates used are from 13/32 to ½ inch thick. The quality of the plate used in the construction will also have some bearing on the length of time a patch will hold over the fire. In putting on a patch over the grate area you create a condition there equally as bad as the short circuit in the front end. You have a double thickness of plate which the water will not protect, and you get the same bad effects as in the front, that is, fire cracking. You can only use a single seam with any degree of success at all where it comes in contact with the furnace fires, and they are, as a rule, put on this way. The inspector comes to make his examination, he finds the patch over the fire and he begins to figure. Logically he can only figure the strength of the boiler from its weakest point, then you have a boiler which is no safer than one would be single riveted, and the inspector cuts down your steam pressure, which means that with other boilers in the battery you will have to cut this one off or reduce the pressure on all.

RELATIVE COST OF HALF-SHEET AND PATCHES.

Let us figure a little on the cost of a half-sheet: On a 150-horsepower boiler, a plate large enough to place all seams far enough away from the furnace to overcome the fire cracks will be about 100 by 110 inches. This will place the girth seam about 2 feet back of the bridge wall, and I have never had any trouble when this was done. The average cost of a plate of this kind will be about $300. Now let us figure a little on the cost of a few patches. It does not take much of a plate on one of those large boilers to cost $100. In a month or so, word comes over the wire "Your patch is leaking, send a man to calk it"; the result: one day's labor and expense, $7; cost of patch, $107. A month or so later the boiler maker is again sent for, whereupon he makes his second trip to calk the patch, but when he gets there he reports back to the shop "Rivets and calking all sprung, will have to be reriveted." This is finally done and the boiler fired up again, cost of this about $30, cost of repairs so far $137. This would cover a period of about six or eight months. A little later word comes again to send a man to see what can be done with the patch. His report is "you will have to have a larger patch, the plate is all fire cracked and the calking edge is cut down to the rivets." This is finally put on at a probable cost of $150. Total cost of repairs for twelve or eighteen months $287. Then you have the same condition over and over, and finally in the end, after spending $400 or $500, it is necessary to put in the half-sheet, making the cost of repairs three times more than the first cost of the half-sheet, and this does not figure the loss of the boiler when idle, which is often greater than the cost of the repair work. My advice is, put in the half-sheet.

CORROSION AND CRACKS.

One of the most dangerous conditions with which the operator has to contend in the use of steam boilers is the corrosion that sometimes takes place along the shell on the inside of return tubular boilers. This takes place below the top row of flues, and you cannot keep track of this action except by frequently taking some of the tubes out so the shell can be inspected.

Another dangerous condition is when you have a horizontal seam below the top row of flues cracked from hole to hole on the inside. Many boilers have seams below the top row of flues, and if a seam of this kind leaks, the safest way is to take out enough flues so a practical man can inspect it. Sometimes a trained eye fails to detect a fracture of this kind, for more or less scale always covers this place. Where you have a leak of this kind, and a competent man fails to detect a crack in the plate, have a good boiler maker chip and calk it, then if it leaks again shut the boiler down at once, for you may be sure you have a condition there that is dangerous. Strip the boiler at this place, cut out the rivets, take a sledge and give it several good blows, and ten to one you will find where the defect is—in most cases on the inside lap from hole to hole, or along the calking edge. Do not take any chances with a defect of this kind.

CORRUGATION OF THE BOTTOM SHEETS.

Any foreign matter which will prevent the water from protecting the plates will be destructive—scale of all kinds, oil of all kinds, if you get too much of it in the boiler. Many good men will take issue with me on the oil question, but in all my experience I have never found where I thought oil was a benefit to the boiler. Where all precautions are taken to prevent the oil from getting in the boiler, that is, where separators are used, no bad effects will be noticed for a long time, but sooner or later, when enough oil gets in to prevent the water from protecting the plates, the bottom of the boiler will start to corrugate, although at first it would take an experienced eye to detect it. It will not be necessary to go under the boiler with a straight edge to discover this. The first indication you will have when your boiler starts to corrugate, will usually be that the few flues which surround the manhole in the bottom of the front head will leak a little, and you will be unable to keep them tight for any length of time. They will not leak very badly but just enough to annoy you. Take out your manhead and look at the rods which run from head to head. If they are slack or bowed up or down, you may be sure the bottom of your boiler has begun to corrugate. If it is due to a scale formation, chip it off; if oil, scrape it off. Whatever it is get it all off.

The action of heavy oil in a boiler may be of interest to many who read this. We will take a condition where care is not used and lubricating oil gets into the boiler day after day. At first the circulation of the water carries the particles of oil around and around, so that they come in contact with other formations, come in contact with their own kind, adhere to each other until they become so heavy they sink to the bottom and the heat from the plates dissolves them. They soon coat the whole bottom of the boiler. This is a condition I have found on several occasions, and again when you have a condition of this kind with a seam over the fire, the plates will come and go at this seam and cannot be kept tight. The rivet holes will become elongated from this action, and you will soon have to make repairs. It is bad practice to run a boiler night and day for a week, and at the end of the run bank your fire until Monday morning, and then start up again without cleaning the boiler. Do not do this. When you shut down always draw off the water, take out the bottom manhole plate and clean out the boiler. You may practice this for some time without experiencing any trouble, but some morning you will start this way, and before you go very far you will have a hole bagged through in the bottom. When your boiler is steaming, the water in action will prevent the sediment and foreign matter from settling, but when the water comes to rest whatever sediment is in circulation will be deposited on the bottom of the shell, and if this formation is very dense you will bag your boiler, for you will be unable to create attraction enough to raise this and start it in circulation again. The result is a patch.

SCALE FORMATION.

Another condition which confronts the operator is the scale formation which adheres to the tubes and shell. If there is any virtue in the different compounds which are on the market for the cure of this evil they should be used when the boiler is put in commission, and if good results are attained continue to do so. But after the scale has accumulated in the boiler and surrounds the shell and tubes, I believe it is bad practice to use any chemical that will precipitate the scale from the tubes to the bottom of boiler. You take big chances of bagging the bottom, and when the boiler is bagged the cure will be worse than the disease. Until some bright mind finds a better method, my advice would be: not try and run the boiler too long when you have a heavy scale formation. You not only take a chance of bagging the boiler but you will ruin your back flue sheet as well. When scale enough gets in around the tubes or the back head, this will prevent the water from protecting the head and it will soon crystalize, then when you go to expand or set new tubes the bridges are likely to crack. Cut the tubes out, clean the boiler thoroughly, put in a new set of tubes or have some reliable firm safe-end the tubes again and reset them in the boiler. When tubes are safe-ended, and the work is done in a proper manner, they will be good and sound and fit for any service. This kind of work, however, should be entrusted to some firm that is well equipped for such jobs. Boiler tubes which are repaired by hand are not fit to use in a boiler. It is a crude way of repairing them, and there is always too much stock at the union, and when taking a welding heat the tube is hammered in the fire while in this state and the extra stock is driven to the inside of the tube. When taken from the fire, if too large at this point, the tube is set in a swedge block, and set as nearly to size as possible. This process has a tendency to weaken the union, as this method of repairing boiler tubes simply sticks them together. It does not weld them, and the extra stock is driven to the inside, which makes the diameter of the tube from ¼ to ½ inch smaller at this joint. Gases in transit from the furnace deposit the waste at this narrow place, soon filling up the tube and cutting down the heating surface.

EFFECT OF FORCED DRAFT ON THE BOILER AND STACK.

Another question which enters into the wear and tear of power plants is forced draft. To begin with, forced draft that can be used in a short cast-iron stack away from the furnace, I believe, has no bad effects other than the wear and tear from the increased duty the method calls upon the boiler to perform. This same arrangement, used in an iron or a steel stack, will destroy it very quickly, especially if the tubes leak badly from time to time. Steam going up the stack from any source will destroy it.

Air drafts of any kind which are used jointly with furnace fires have a bad effect on the bottoms of boilers, particularly where a boiler has a seam over the fire. A mechanical stoker may eliminate this to a great extent. It deposits the fuel evenly over the grate at all times, and there is not much chance of a hole blowing in the coal bed, but with hand firing the fireman is not as careful as his mechanical friend, and he frequently has a hole blown in his fire. If there is a seam near the draft, contraction of the plates takes place suddenly and the seam leaks at once, and it will not be long until you are unable to keep this joint tight.

In the use of steam jets there is no question but what the operation, as applied, generates the steam into a gas. After leaving the jet it is partly condensed, but in passing it through 2,500 or 3,000 degrees of heat, it becomes a superheated gas, and it is my judgment that it remains so until it gets up into the higher altitudes and then returns to its original state—water. Now, if this is true and this condensation takes place before it leaves the stack, there is a certain amount of moisture which adheres to the stack and soot which contains more or less sulphur, and I believe there is no more destructive chemical known to the average coal operator than the two elements mentioned—water and sulphur. This may be the cause of the rapid destruction of many steel stacks. This is an open question, and I am not stating facts, but simply giving my opinion. There are so many problems which enter the field when it comes to the wear and tear of stacks that the average man will be unable to solve them.

Design and Construction of a Marine Boiler.

While the design of a boiler is of importance, it is doubtful if it is more important than the manner of construction, whether the safety of the boiler or the profits of the manufacturer is considered, and it may not be out of place to describe some of the difficulties met in the shop in building a boiler after the drawing room has successfully produced it on paper.

The boiler in question is of the water-back marine type, designed to carry a working pressure of 150 pounds per square inch. The shell is 10 feet in diameter and 11½ feet long, of marine steel .70 inch thick, having a tensile strength of 65,000 pounds per sectional square inch, and is of two courses, one sheet to the course. The longitudinal seams are quadruple butt joints, with 1⅛-inch rivets, 1 3/16-inch holes, with centers pitched 16 inches in the outer row. The outside butt strap takes in two rows of rivets on each side of the joint, while the inside strap extends from outer row to outer row, embracing all of the rivets in the joint, as is common practice in this country. The butt straps are ½ inch thick. The boiler heads are of ¾-inch steel, with all flanges turned inward. The inside tube sheet is ⅝ inch thick. The combustion chamber is 24 inches deep and the wrapper is of 9/16-inch plate. The stays are 1½ inches in diameter, threaded 12 threads per inch and spaced 7½-inch centers, both in the wrapper and the rear head. The crown bolts are 1½ inches in diameter, 12 threads per inch, with full-size nut on the fire side. The crown bolts are threaded into the crown sheet and supported by crown bars. The stay-bolts and crown bolts have ⅛-inch telltale holes extending ½ inch inside of the inside face of the plates. There are 142 tubes, 3½ inches in diameter and 9 feet long, of knobbled charcoal iron. The tubes are spaced 4½ inches vertically and horizontally, allowing a 1-inch bridge, with the exception of the center vertical bridge, which is 3 inches wide. There are two Morison corrugated furnaces, each 36 inches in diameter, 9 feet long and 13/32 inch thick. The grate surface is 21 square feet per furnace, or a total grate surface of 42 square feet. The total heating surface is 1,413 square feet; there being 1,170 square feet in the tubes, 85 square feet in the top half of both furnaces, and 158 square feet in the combustion chamber. The ratio of grate surface to heating surface is 1 to 33.6. The boiler is rated as 150 H. P., or 1 H. P. to 9.4 square feet of heating surface. The portions of the boiler heads to be braced are reinforced by ½-inch doubling plates, and the stay rods are pitched 14-inch by 15-inch centers. There are 1,847 square inches to be braced, to support which eight 2¾-inch diameter through-rods are used. The through-rods are not upset, and, being cut 6 threads to the inch, there is a diameter of 2.53 inches at the root of the threads.

The following calculations determine the safe working pressure of the boiler, and are based upon the finished boiler, rather than upon the data given on the working drawings furnished the shop by the engineering department. The

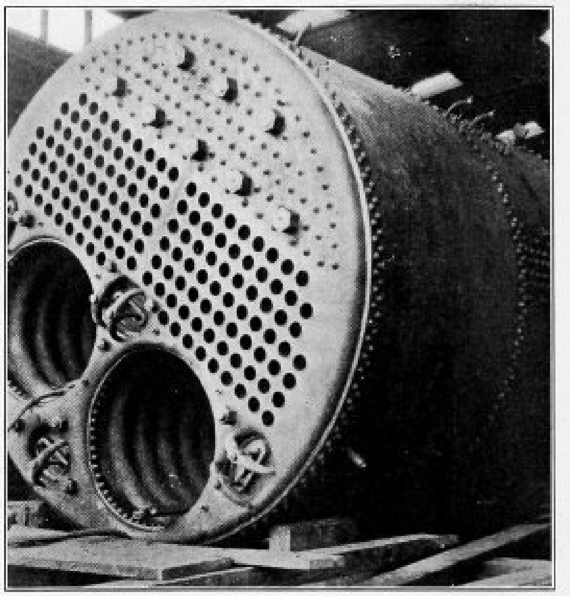


FIG. 1.—THE COMPLETED BOILER.

method used to determine the bursting pressure of the longitudinal seams is the one in almost universal use, and is expressed by the following formula:

$$\frac{t \times TS \times \%}{R} = \text{bursting pressure of seam, and}$$

$$\frac{\text{bursting pressure}}{\text{factor of safety}} = \text{working pressure,}$$

or the thickness of the shell plates multiplied by the tensile strength and by the efficiency of the seam and divided by the radius, or one-half the diameter of the boiler, gives the bursting pressure. The latter divided by the factor of safety, usually expressed by the letters *F. S.*, gives the safe working pressure.

It will require several calculations to determine the efficiency of the seam. The relation of the net section along the line of holes in widest pitch, as shown by dotted line *E......F*, Fig. 2, is found by subtracting the diameter of the rivet hole from the pitch of the rivets, and dividing the difference by the pitch, or as expressed by the formula, $\frac{P - d}{P}$ = percent, which, substituting, we find to be $\frac{16 - 1\ 3/16}{16} = 92.5$ percent, or the material remaining along this line, after the holes are cut, is 92½ percent of the original amount. We are often told that in the butt joint type of seams, the strength of the net section represents the strength or efficiency of the joint, on account of the strength of the riveting being, in many cases, greater than the strength of the solid plate. By carrying the calculations a little further it will be seen that with heavy plates and large rivets the net section is stronger than some other parts of the joint.

The strength of the rivets, in shear, in this seam, is found by using the Philadelphia rule, which is expressed as follows: Multiply the strength of one rivet by the number of rivets, in a part of the seam the length of one rivet pitch, and divide by the strength of a section of the plate, the width of one rivet pitch. Considering the strength of a rivet in double shear to be 1.8 as strong as a rivet in single shear, and the shearing strength of rivets in single shear to be 42,000 pounds per sectional square inch, we find 46,516 pounds to be the strength of a 1 3/16-inch diameter rivet, and as there are three rivets in single shear and eight rivets in double shear in each distance of 16 inches along the seam, the rivet shear is 10 percent greater than the solid plate, for

$$\frac{(3 + (8 \times 1.8))\ 46{,}516}{16 \times .70 \times 65{,}000} = 110 \text{ percent.}$$

By considering the strength of the section through the intermediate row of rivets as at *A......B*, Fig. 2, and the rivets in the outer row, we find a much smaller efficiency for the joint. It will be seen that should the seam fail through the net sections along the line *A......B*, it would be necessary for the rivets in the outer row to fail at the same time, so the strength of these rivets should be added to the net strength along this line. The rivet is in single shear, and 46,516 pounds represents its ultimate strength. The net section is found by subtracting the diameter of two rivet holes from the pitch, leaving 13⅝ inches of solid plate, which, multiplied by the thickness to get the area and by the tensile strength of the steel, gives the strength in pounds of the net section. To this add the strength of the rivet and divide the whole by the strength of a strip of plate 16 inches, or one rivet pitch wide, and we find the efficiency of the joint at this place to be 90 percent of the solid plate. Expressed mathematically we have

$$\frac{46{,}516 + ((65{,}000 \times .70)\ (16 - [2 \times 1\ 3/16]))}{65{,}000 \times .70 \times 16} = 90 \text{ percent.}$$

By considering the net section through the first inner row of rivets, as at *C......D*, Fig. 2, and the shear of the rivets in the outer row and the intermediate row, we find the lowest efficiency of the seam. There are four rivet holes to be subtracted from the pitch, or 16 inches, minus 4 by 1 3/16, which leaves 11¼ inches of solid plate; to this is added the strength of three rivets in single shear. As when considering the last efficiency, we divided by the strength of the plate the width of one rivet pitch. This is expressed as follows:

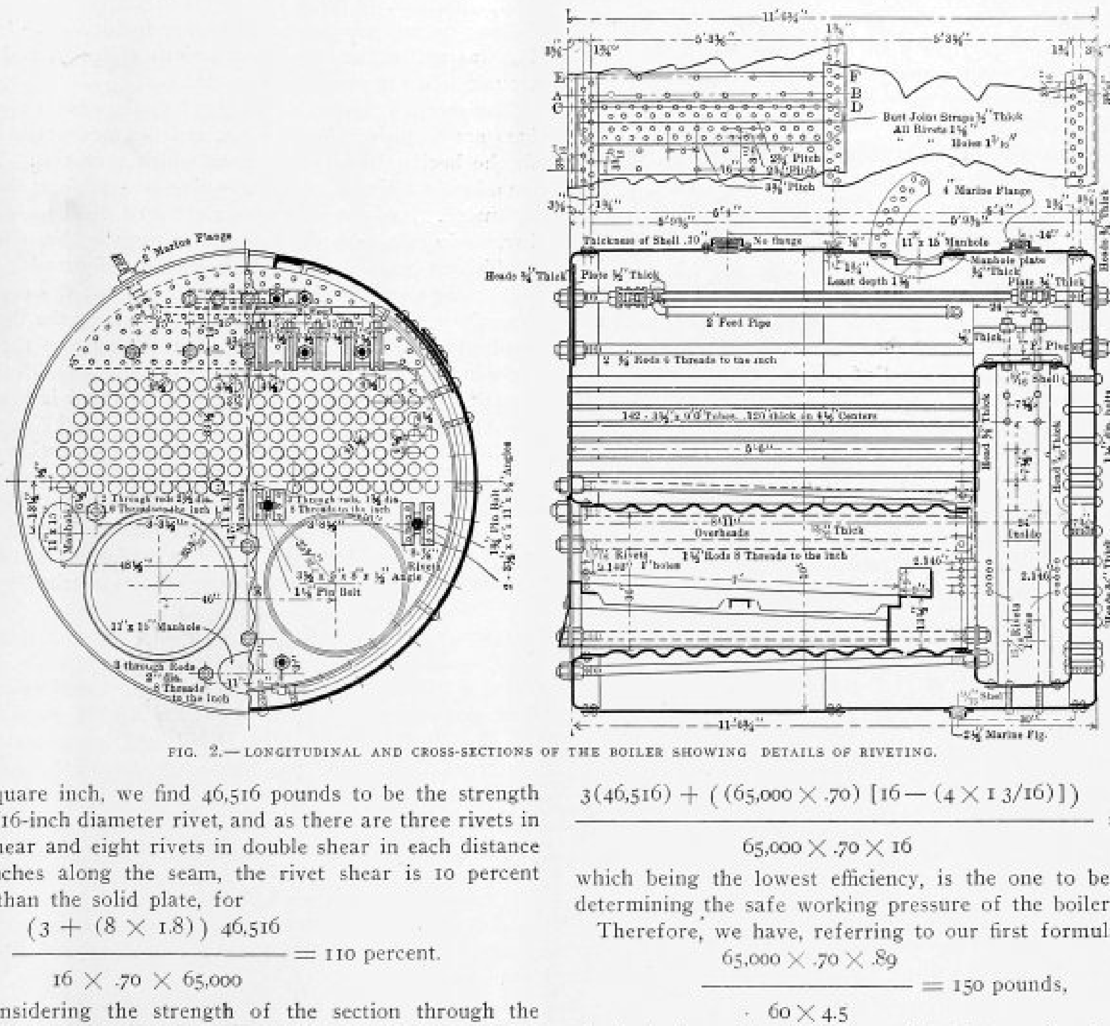


FIG. 2.—LONGITUDINAL AND CROSS-SECTIONS OF THE BOILER SHOWING DETAILS OF RIVETING.

$$\frac{3(46{,}516) + ((65{,}000 \times .70)\ [16 - (4 \times 1\ 3/16)])}{65{,}000 \times .70 \times 16} = 89 \text{ percent,}$$

which being the lowest efficiency, is the one to be used in determining the safe working pressure of the boiler.

Therefore, we have, referring to our first formula,

$$\frac{65{,}000 \times .70 \times .89}{60 \times 4.5} = 150 \text{ pounds,}$$

the desired working pressure with a factor of safety of 4.5. This boiler, according to the rule of supervising inspectors, would carry 216 pounds, providing the other parts of the boiler were designed and constructed according to their requirements for that pressure; as will be seen by dividing the tensile strength by six and multiplying by the thickness, the product to be divided by the radius of the boiler, to which 20 percent is added for double riveting. The calculations regarding the efficiency of the joint might have been carried further, and net section along the second inner row of rivets considered. To this strength would be added the rivet shear of the rivets in the other rows, and on account of the first inner row of rivets being in double shear, the efficiency of the joint is about 50 percent greater than the strength of the solid plate.

We will next consider the allowable working pressure upon the stays. Taking 6,000 pounds per sectional square inch as the safe load the safe working pressure will be

$$\frac{1.44 \times 6{,}000}{(7\frac{1}{2})^2} = 154 \text{ pounds,}$$

where 1.44 is the sectional area at bottom of the threads in square inches, of a $1\frac{1}{2}$-inch diameter stay-bolt, cut 12 threads per inch, and $7\frac{1}{2}$ inches pitch of stays. The crown bars would safely carry 168 pounds pressure, as shown by the following calculation:

$$\left(\frac{825 \times (7)^2 \times \frac{1}{2}}{(24-8) \times 7\frac{1}{2} \times 2}\right) 2 = 168 \text{ pounds,}$$

where 825 is the constant used, where two supporting bolts join the crown bars to crown sheet, 7 inches is the depth of each crown bar and ½ inch the thickness, 24 inches is the length of the bars and 8 inches the distance between the crown bolts, $7\frac{1}{2}$ inches the distance between the crown bars and each crown bar is double.

The pressure all~wable on the area supported by each crown bolt is found as follows:

$$\frac{135 \times (9)^2}{(8)^2} = 170 \text{ pounds,}$$

in which 135 is the constant used when there are nuts on the fire side only; 8 inches is the greatest pitch of the bolts and the sheet is 9/16 inch thick.

The strain on the tube sheet of the combustion chamber is shown by the formula

$$C = \frac{P \times D \times W}{2(D-d)\ T}$$

in which P is the pressure; d, distance between tube centers; W, width of combustion chamber in inches; d, inside diameter of tubes, and T, thickness of tube sheet. We find by substituting the real values for the letters in the formula,

$$\frac{150 \times 4\frac{1}{2} \times 24}{2(4\frac{1}{2} - 3.26)\ \frac{5}{8}} = 10{,}470 \text{ pounds,}$$

which is well within the limits, as 13,500 pounds is the greatest allowable strain.

The area of the boiler heads above the tubes to be braced being 1,847 square inches, and supported by eight $2\frac{3}{4}$-inch diameter through-rods, not upset, and cut six threads per inch, 162 pounds is the working pressure, if 7,500 pounds per sectional square inch of brace area is allowed for steel rods not welded.

Using the supervising inspectors' rule for the Morison furnaces, those which are 36 inches diameter and 13/32 inch thick will carry 175 pounds, viz.:

$$\frac{15{,}600 \times 13/32}{36} = 175.$$

Each of the furnaces has drilled holes near the center, to facilitate taking its thickness, after it is in the boiler. This practically completes the mental contortions necessary in the engineering department to determine the design of the boiler, and we will now learn how the work was put through the shop.

The laying out of the sheets was accomplished without serious difficulty with one exception, which will be referred to later. On account of the length of the shell plates some trouble was experienced in handling them. Each machine in the shop is equipped with an air lift, and the use of two lifts was necessary at the punch and shears and drill presses. As much as possible of the handling was done with the electric traveling crane, but this does not serve all of the machines. Several passes through the rolls were given before the proper curvature was reached, and the strains upon the rolls were great, on account of the manner in which the weight was thrown upon them.

The furnace nozzles, which were flanged by hand, in the front head were turned in, as also was the edge flange. This caused considerable extra work, as blocks had to be shaped to fit between the flanges, and it was difficult to keep the edge flange from warping when heats were being taken on the nozzle flanges. This trouble was again met when the manhole reinforcements were being turned.

After the combustion chamber had been fitted up the blank head was riveted to the wrapper by the hydraulic riveter, but the head containing the furnace nozzles could not be riveted in this manner. A hook and sledge arrangement was used for holding on and a long-stroke hammer for driving. This riveting was accomplished without serious difficulty, and gave no trouble when the boiler was tested.

The crown bars were then fitted to the crown sheet. The bars are of ½-inch boiler plate, and the toes were chipped to fit the heel of the flanges upon which they rest. This was found to be a big proposition, costing several times the amount estimated. Had wrought toes, riveted or welded to the crown bar, as is customary in locomotive practice, been used they could have been heated, and a good fit easily made.

Tapping the holes in the crown sheet for the crown bolts was given great care, it being desired to keep the tap at right angles to the crown sheet, but when the nuts on the fire side were in place they did not have as good contact with the crown sheet as could be wished. Work of this kind is better when done under a drill press.

The furnaces were next riveted to the combustion chamber, and as they had not been put into the shell there was ample room for properly holding on the rivets. As the furnaces had all of the holes in them, after the combustion chamber and furnaces had been placed in the shell, the front head was drawn into place, and the furnace holes marked off. They were then taken apart, the holes in the nozzles drilled, and the front head riveted to the furnaces before the boiler was again assembled. This method of procedure calls for some extra work, but it insures good holes and well-driven rivets. The girth seam and head seams are double riveted, as will be seen by referring to Fig. 2; only the front head seam remained to be driven, the other seams having been driven on the hydraulic riveter. An attempt was made to drive the front head seam with a long-stroke hammer, holding on with an air dolly bar, but this method was abandoned on account of the inability to fill the holes. All of the rivets driven with the long-stroke hammer had to be cut out, as they could be shaken in the holes when cool. The hook and sledge was then used for "bucking up," and a snap and sledge for driving with good success.

The air pressure used with the long-stroke hammer and air dolly was 110 pounds. The piston of the dolly has an area of 12 square inches. The hammer is 8 inches by 1 1/16 inches. As trouble has been experienced in many shops with long-stroke riveters, when thick plates and large rivets are used, it is reasonable to conclude that if tight work is called for the hook and sledge for holding on and the sledge and snap for driving must be used. It was necessary to flatten the heads of several rivets in the nozzle seams to permit the manhole plate to come into place. This was due to the size of the manhole, 11 inches by 15 inches, and the small space between the nozzles and edge flange. Had the front head been backed in, as is often the case, the trouble with the rivets in the head seam would have been avoided, as they could have been driven on the hydraulic riveter, and there would have been more space for the manhole openings.

For calking this boiler a heavy stoving tool and round nose, or fuller, were used. The combustion chamber was calked inside and out. The stoving tool was of no value, except to smooth up the edge of the plates, which had been bevel sheared. The tools were air driven, and no trouble was experienced in getting the seams tight. On the test small, fine square tools were used to stop such pin holes as appeared. The hydraulic-driven rivets gave no trouble, although but 75 tons pressure was used, which is somewhat less than is usually used with 1⅛-inch rivets.

When the through braces were put in it was necessary to use an arrangement to keep the middle rod in the upper row out of the way of the manhole opening, and it is here that the only trouble caused by the laying out of the boiler was met. The manhole opening in the shell should have been off center, as shown by the dotted lines, Fig. 2. However, this was overlooked, and had the through rods not been changed the manhole opening would have been of no value. The 2¾-inch rods were shortened and connected to two crown bars, the crown bars being tied together by two 2¼-inch rods, details of which, as it appears at either boiler head, is shown in Fig. 3. This arrangement has a large margin for safety, as its safe load is 55,500 pounds, while the safe load upon the through rod is but 37,500 pounds. Some difficulty was encountered in getting the proper tension on this crown-bar arrangement, but by having the workman make several trips into the boiler for that purpose, it was finally satisfactorily adjusted. The braces below the furnaces extend through the tube sheets in the same manner as the braces above the tubes, and the braces between the tubes and furnaces were secured at the rear ends with a pin bolt, blade and jaw, the blade being welded to the braces and the jaw, formed of two angle-irons, riveted to the tube sheet.

Serious trouble was encountered with stripping stay-bolts at the inner sheet, about fifty having to be removed and the holes tapped for 1¾-inch bolts. Investigation proved the trouble to be due to the creep of the threads on the stay-bolts, and a difference in the threads on the taps. In a distance of 6 inches one-half thread would be gained, which, in a heavy sheet, means a stripped thread when the inside sheet is reached. With plates of 5/16 inch thickness trouble is sometimes met, but unless the hole is near a flange, which makes the sheet very rigid, the sheet will usually spring sufficiently to allow the threads to engage, but with plates ½ inch and over the threads will strip before the sheets will spring. One stay-bolt, which entered the outside sheet easily, could not be turned with a 4-foot wrench when the inside sheet was reached. However, when this bolt was started from the inside sheet an air motor pulled it until the outside sheet was met, when it refused to go farther, and when forced to do so stripped both the hole and bolt. It is up to the makers of stay-bolt taps and hob taps to look well to the lead screws of their lathes when taps of large size are made. The taps on this job took hold of the inner sheet before the outside sheet was released, so, practically, a continuous thread was obtained, and had the threads upon the taps and the stay-bolts matched there would have been no trouble. Very little argument is necessary to convince the average engineer that no matter how nicely the safe load upon the bolts is calculated by the drafting department, unless good threads are obtained the boiler will not be safe, nor will it give satisfactory results.

The stay-bolts were driven by hand and the heads rounded up with a set, after a failure had been made with air driving on account of the dies used with the air hammer not standing the work. Many of them were broken in the cup. The trial of the job was encountered in drilling telltale holes in the stay-bolts and crown bolts. As has been stated, these extend ½ inch inside of the inside face of the sheets, and the stay-bolts were drilled from each end. The back head being ¾ inch thick, the head of the stay-bolt about ⅜ inch high, and the hole extending ½ inch inside of the sheet, the holes were 1⅝ inches deep and but ⅛ inch in diameter. Hand breast drills and air breast drills were used, and with the latter two holes an hour were possible, while with the former an average of about one and one-half holes an hour was made. The breakage of drills with the air drill was much greater than with the hand drills, and much time was lost in fishing out the broken points, so the hole could be completed. Many of the drills were broken and reground half a dozen times, so it is not possible to tell just how many drills were broken, but 12 dozen new drills were broken, or rather, destroyed, 13½ dozen having been purchased for the job.

The accompanying photograph gives a good view of the front head of the boiler as it appeared on the temporary test blocks. On account of the weight of the finished boiler it

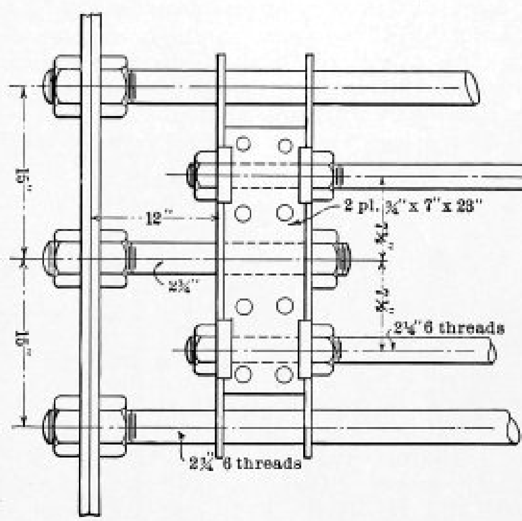


FIG. 3.—DETAILS OF THROUGH STAYS IN WAY OF MANHOLE.

was moved as little as possible; but, contrary to expectations, there was no trouble in loading it on the car. The double riveted head and girth seams may be seen and also a part of the quadruple butt longitudinal seam.

Too little is usually said regarding shop methods, and too much importance given the designing of boilers. While it is undoubtedly necessary that proper attention be given the kind of material used in the construction of a boiler, it is of equal, or greater, importance that such material as is used be not injured by poor methods of manipulation during the process of construction. If the gage of the steel for a boiler is too light for the pressure it is not hard to arrive at a conclusion as to what pressure should be carried, but if the steel is injured at some point which is inaccessible when the boiler is completed, it is often found out at the coroner's inquest. It will be seen that if stay-bolts have no threads they would resemble very closely those with perfect threads after the boiler had been completed, provided, of course, that they did not leak.

Careful inspection is necessary in the shop if the factor of safety called for in the specifications is to be even approximated, and the purchasers of boilers are awakening to the importance of having a representative present during the whole process of construction. This condition has been met by many of the boiler makers arranging to have their output examined by the steam boiler insurance inspectors. Sometimes the shop superintendent thinks the inspector too strict, and occasionally a purchaser thinks him too lenient and the work not as smooth as it should be, but if each will think of the fractured plates, stripped stay-bolts, defective rivets and poorly welded braces, marked for removal, both will consider the shop inspection as an indispensable part of the boiler contract, and that both the purchaser and builder are protected by rigid shop inspection and first-class shop methods.

Flanging Boiler Plates.—I.

BY FRANK B. KLEINHANS.

Early Methods of Flanging.

Flanging boiler plates is such a common thing at the present day that we hardly think of the time when the work was done without hydraulic presses and elaborate heating furnaces. In early times, plates had to be flanged by hand. The means they had in those days for heating the plates were limited. In most cases the plates were heated in an open fire, with coke built up to hold and give out heat. When the plates were heated and removed, the coke walls were more or less broken down, so that in order to reheat the plate the fire would have to be built up again.

The method of handling the plates was quite different at that time from what we use to-day. In most cases the plate was suspended from a jib crane of light construction, which had a trolley running on a flat bar, and a differential block was used to raise and lower it. In many cases the jib was provided with a plain chain with a forged eye, to which two or three chains were attached. The plate would be lifted up by several men and hooked fast to these chains. It would then be shifted into the fire and heated and swung over to the anvil or former. The hot plate would be handled by several men with grip bars as shown in Figs. 1 and 2. Curiously enough these bars have not been improved on very much, for one can see them about the forge shop of to-day, and indeed it would be difficult to get along without them. Even in modern hydraulic flanging presses, they are used to shift the plates and to set it to gage.

One thing can be said in favor of early flanging. The boilers in those days were smaller and worked under less steam pressure than those of to-day, consequently the sheets were smaller and thinner. I am afraid if we had to resort to hand flanging altogether to-day, that the very thick sheets which are required would make flanging almost out of the question. The early boilers were also very simple in design when compared with those that have been built within the last five or six years. Fig. 3 gives a good idea of the simplicity of one of these boilers. The back head, throat sheet, back fire-box sheet and back top sheet were plain sheets,

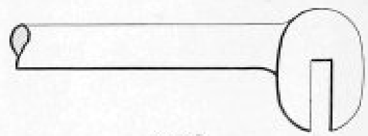


FIG. 1.

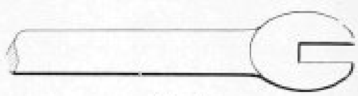


FIG. 2.

placed at right angles to the center line of the boiler, the outer edge being flanged down to give a fair surface for riveting and calking. The front tube sheet was round, with the edge flanged. The dome sheet was frequently flanged out directly and riveted to the boiler. Thus we see that the flanged sheets of such a boiler were simple in design, but with the meagre apparatus at hand, even this work was often difficult.

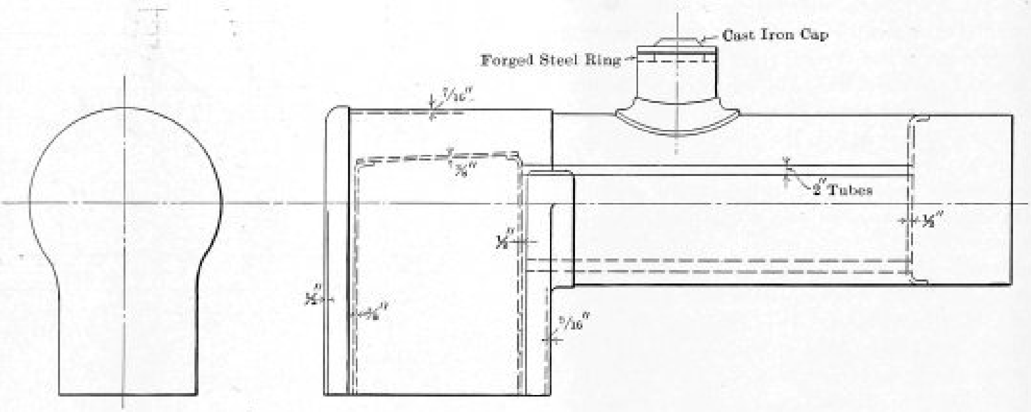


FIG. 3.—THE FLANGED SHEETS IN EARLY BOILERS WERE SIMPLE IN DESIGN.

Probably the simplest sheet to flange was the front tube sheet. The sheet was first heated up, say, about one-third of the outer circumference and then placed over a cast-iron former *F*, Fig. 4. *P* is a pin for centering the plate and to help hold it in position. *C* and *C* are clamps, which were put near the heated part for the purpose of keeping the sheet from buckling up, while the outer edge was being pounded with heavy mauls. After the flanged head has been worked down as far as possible for the heat, the sheet was unclamped and put in the fire; another section heated, pounded down and so on all the away around. Oftentimes bad places would occur where the flanged edge would not work down evenly. This was due to flanging the sheet in sections and under the circumstances could hardly be avoided. These places would have to be reheated, and the metal would have to be upset in order to get it "back home." A considerable margin was left

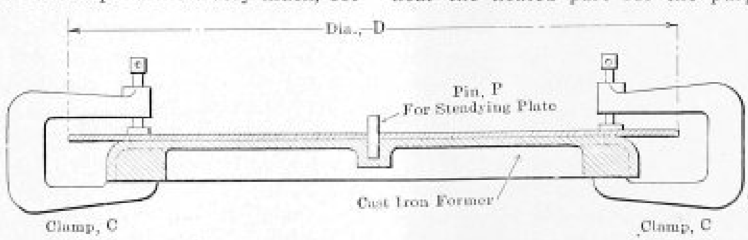


FIG. 4.—METHOD OF FLANGING FRONT TUBE SHEET.

on the sheet to be sure that the flange would not "run shy." This extra metal was then turned off and the sheet was laid out and punched.

Probably the next sheet in the order of difficulty would be the back fire-box sheet. This would be about ⅜ inch thick and would be comparatively easy to flange. Where several boilers were being made, either at one time or at different times throughout the year, a former would be made of cast iron, see Fig. 5, either in one piece or bolted together. The sheet would be suspended from a lever, as shown in Fig. 6. One man could then raise or lower the plate into the fire or onto the former as occasion demanded. The lift chain could be shortened by dropping the plate on a support, the hook of the lever could then be put several links lower. Ordinarily the variation of height between the heating fire and former was very slight, and once the sheet was hooked up it could be handled with ease until it was finished.

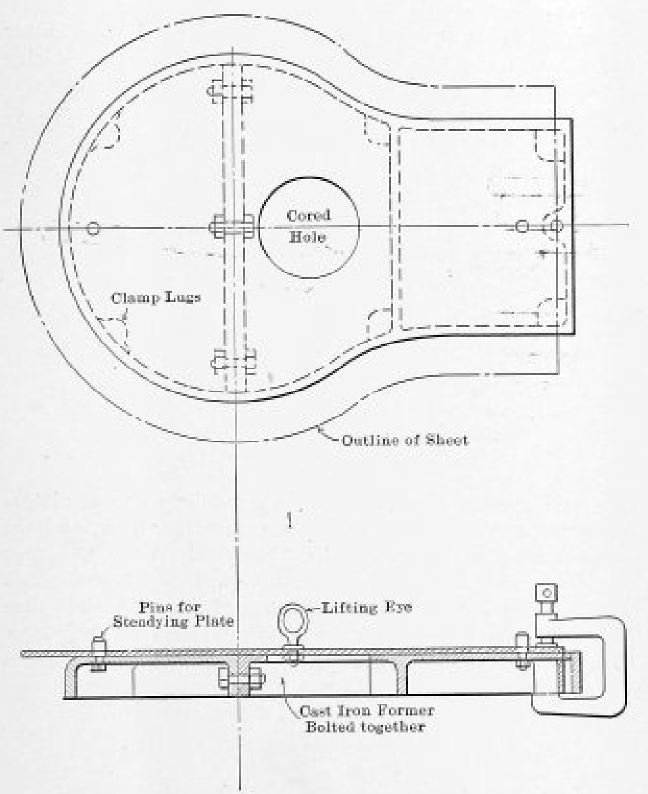


FIG. 5.—METHOD OF FLANGING BACK FIRE-BOX SHEET.

The throat sheet shown in Fig. 7 was a difficult sheet to flange in those early days. The flat sheet was laid out and a line was marked off where the fillet began, as shown in Fig. 8. This was then center punched with a row of holes so that it could be seen when the sheet was hot. The sheet had plenty of stock for trimming after it was shaped up. Referring now to Fig. 8, the part *A* for the central flange was not removed until after the outside flange *G* was hammered down. The sheet was first heated for as large an area as the men and heating facilities would admit, and then clamped over a cast-iron block while the outer flange was mauled down. The boss would try the size of the fillet with a square on which two lines, *A* and *B* Fig. 9, were marked, showing the tangent points where the fillet was to begin. The workmen would then be instructed where to soak the sheet hardest, and where to let up. Oftentimes it was necessary to bring the flange on one side of the sheet down somewhat all along, and then reheat so as to pound it home to the proper shape.

The flatter shown in Fig. 10 was used to even up the bumps, and when this was used extra heavy sledges would replace the wooden mauls. The flatters were either flat or rounded, as shown in Fig. 10, to suit either the outer or inner curve line. After the edge had been clipped smooth, the sheet was heated for the inner flange. It was then placed upside down on a forming plate, which was provided with a flange to which the upper

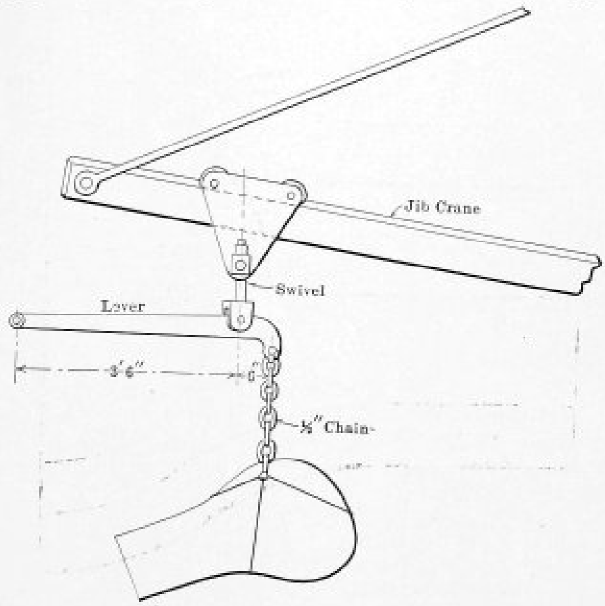


FIG. 6.—METHOD OF HANDLING THE PLATES.

corner *C*, Fig. 7, was clamped. This held the corner from turning over and following after the inner flange when the latter was being hammered down. The corners *C* would often get red hot in the fire, but before putting the sheet on the former they would be dipped in a tank of water and cooled. This made the corners very stiff and rigid so that the clamps would hold better. The entire inside flange was heated and would be mauled down as far as possible at one heat and

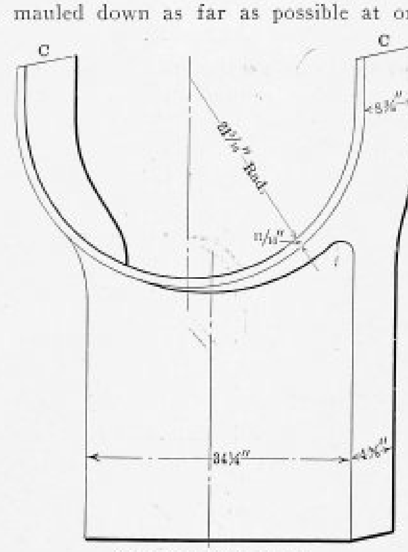


FIG. 7.—THROAT SHEET.

then reheated. The upper flanged portions of the sheet would often be very crooked and twisted. This could be fixed up afterwards by upending the sheet and using the flatter until it was brought to the desired shape.

Probably the most difficult sheet to flange was the outside throat sheet for a Belpaire boiler, Fig. 11. The sheet was laid out and trimmed with the proper allowance for truing up after flanging. It was then cut out on the inside and the edge turned up. The sheet was then heated in the center and clamped over a hollow former having the shape of the barrel of the boiler and filleted to suit what was desired on the inner edge of the flange. The flange was then worked in gradually against the former. When the flange was finished the sheet was heated along the outside edge and placed upside down on another cast-iron former, which had a flange cast on to just

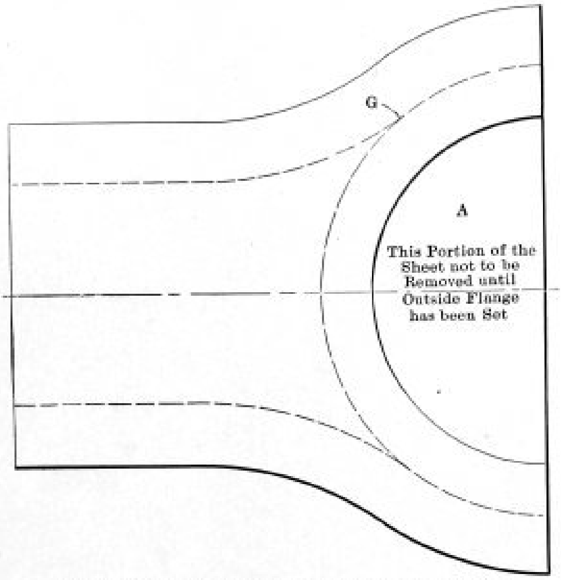


FIG. 8.—LAYOUT OF THROAT SHEET BEFORE FLANGING.

fit the hole which had already been formed. This centered the sheet, and by it the sheet would be held rigidly in place while the outside flange was hammered down. The worst thing on the outside flange was at the corners *G* and *H;* here the metal would be more or less stretched when the top portion was being flanged. When the sides were driven in, the metal would have to be crowded in and upset. This is a mean job and it can only be done slowly and with a lot of pounding.

(To be continued.)

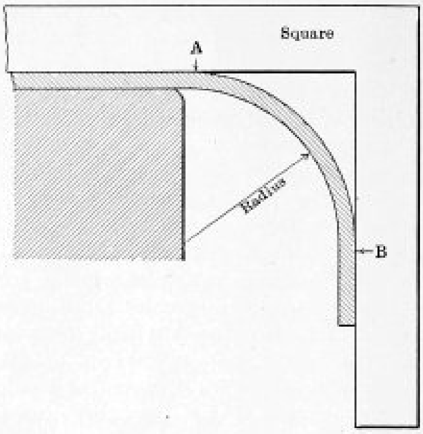


FIG. 9.—GAGING THE FILLET.

The delays to shop operation that are often accredited the individual electric drive for machine tools do not appear to be a serious factor in a completely equipped and well organized shop plant. At the large McKees Rocks locomotive and car repair shops of the Pittsburg & Lake Erie Railroad, near Pittsburg, which are equipped throughout for individual motor driving of tools, the average length of the periods of delay to tools due to motor troubles during the year of 1907 was only about seventeen minutes. While there are a total of eighty-four motors in use for machine driving at these shops,

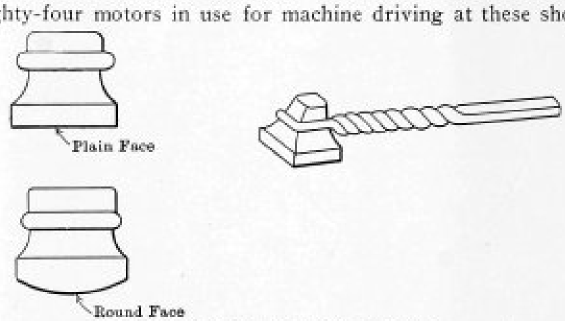


FIG. 10.—PLAIN AND ROUND FLATTERS.

the total number of the above delays for the year was ninety-three, an average of 1.1 delays per motor per year, and the longest delay was but 1¼ hours. The total time of all motor delays to tools during working hours was 26½ hours, which resulted in a loss by enforced idleness of the machinists' time (valued at an average of 27½ cents per hour) of only $7.30. In order to minimize such delays, standard sizes of motors only were installed.

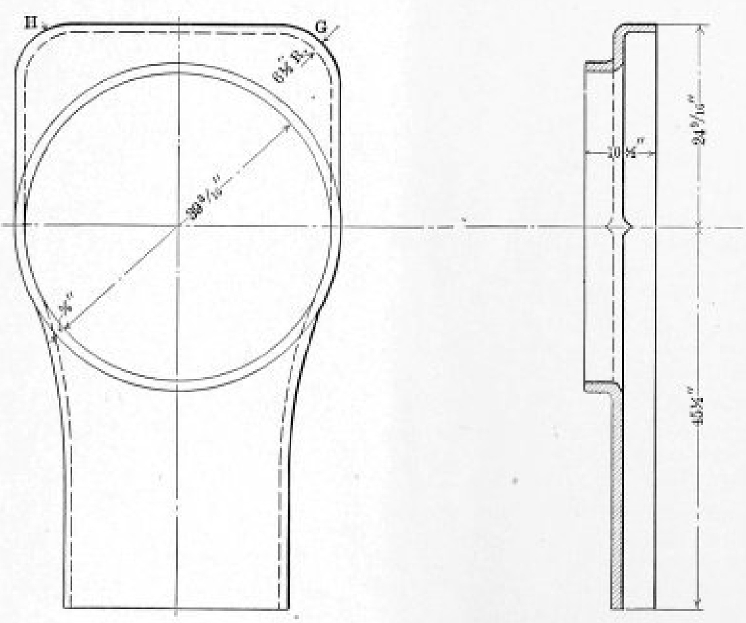


FIG. 11.—THROAT SHEET FOR BELPAIRE BOILER.

Application of Autogenous Welding to Boiler Shop Work

BY L. L. BERNIER, M. E.

BLOW-PIPE WELDING OF STEEL PLATE.

One of the most important applications of oxyacetylene welding is its substitution for riveting and bolting in steel-plate work.

To assemble steel plates, and in general in all cases of assemblage by oxacetylene welding, "marking" is the first operation; it consists in making in various places along the pieces to be assembled several "drops" of welding, in order to maintain the two parts to be united in their respective positions. Then the welding is done in the following way:

AB, AB' are the edges of the two plates to be united, previously marked (Fig. 10).

We suppose that we start welding at *a*, moving forward toward *BB'*. The flame of the blow-pipe is allowed to act at the point *a* until it causes a fusion of the metal throughout the plate at *a;* the metal in fusion affects the shape of a drop. The flame is then brought forward from *a* to *b;* at *b* the same operation is repeated, and so forth.

In fact, the successive fusion drops *a, b, c,* etc., partially cover each other, and after cooling form a homogeneous mass.

The exterior face of the welding alone shows the way in which the work was done by a series of ridges outlining the

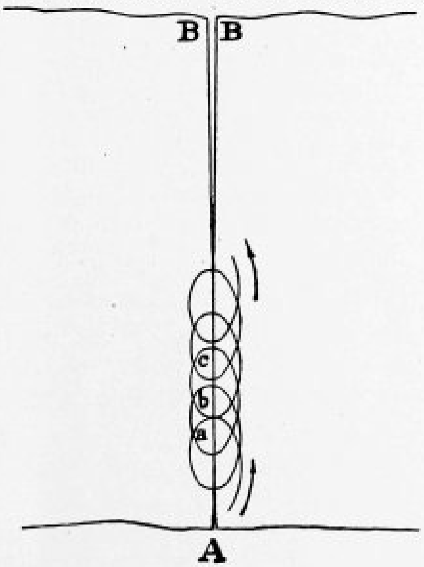


FIG. 10.

successive fusion drops. These ridges are more or less apparent, according to the ability of the workman and to the volume of the fusing drops, the latter being in proportion to the thickness of the plate.

In the assembling of two plates by oxyacetylene welding the quantity of lost metal (by oxidation, for instance,) being exceedingly small, the thickness along the welding line is practically the same as the adjoining parts, if there is no material space between the two parts to be welded. If, on the other hand, there is a space between them, it is necessary, after the edges of both plates have been brought to the melting point, to melt a rod of the metal, which the workman holds in his hand; this supplementary metal falls by drops on the melted edges and increases the melted mass in the proportion desired. The nature of this supplementary metal varies with the result to be obtained. Very often, in order to have an invisible welding line and not to modify the qualities of the metal along the latter, this line is "charged" by means of metal taken from the piece itself, such as strips taken from the plates; more frequently, in the case of iron or soft steel, the "charge" is made by means of ordinary soft steel wire, ⅛ to ¼ inch diameter, according to the thickness of the piece to be soldered. The quantity of metal so added varies with the space between both parts before welding, and with the excess of thickness to be given to the welded part over

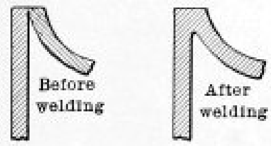


Fig. 11

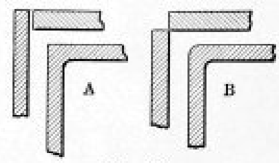


Fig. 12

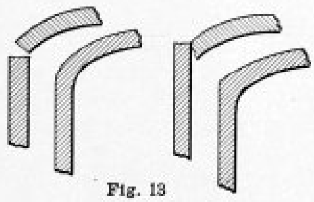


Fig. 13

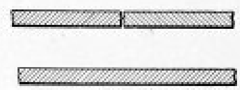


Fig. 14

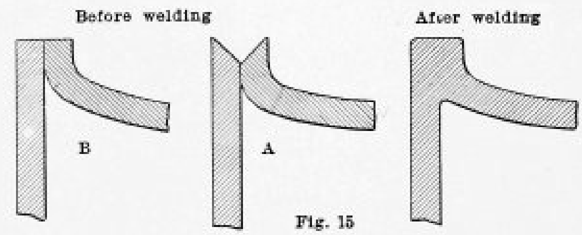


Fig. 15

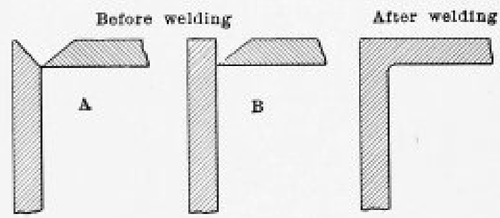


Fig. 16

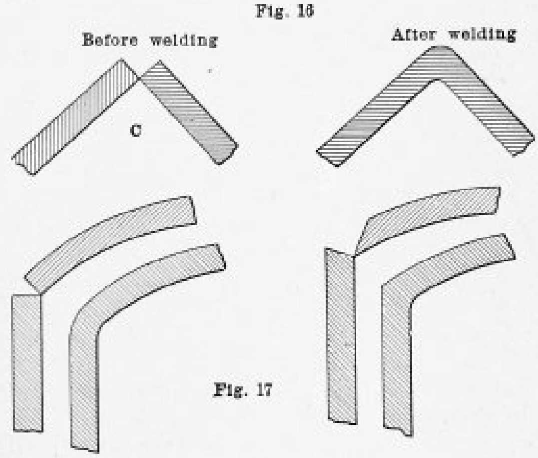


Fig. 17

the adjoining metal; naturally, this excess of thickness may be as great as the particular conditions may require, but in general it is very small, and a little chipping or filing is enough to take away the unevenness and bring the welded part to the level of the adjoining surface.

Thin plates (less than 1/16 inch thickness) to be welded with the blow-pipe require no special preparation of the edges before assembling. The above sketches show the various cases to be considered:

Fig. 11. Angle of the plates less than 90 degrees (concave bottom welded in a shell).

Fig. 12. Angle of the plates about 90 degrees. The assembling may be made, as desired, according to sketch *A* or *B*. Assembling *A* requiring no addition of metal is more rapid.

Fig. 13. Angle of the plates larger than 90 degrees (convex bottom welded in a shell).

Fig. 14. Angle of the plates = 180 degrees.

The welding of plates of more than ¼ inch thickness requires a special chamfering of the edges. These sketches show various examples. In general the preparation must be such as to allow the flame of the blow-pipe to penetrate to the very bottom of the part to be welded; thus, there is no doubt that the entire thickness is affected. If in some cases it is impossible to make such a preparation it is then necessary to proceed slowly, in order to thoroughly fuse the entire section of the metal. In this case it will be better if the plates to be assembled are not in contact but are 1/16 inch apart.

Fig. 15. Angle of the plates less than 90 degrees. Preparation *A* is better than *B*.

Fig. 16. Angle of the plates 90 degrees. Preparations *A* and *C* are better than *B*.

Fig. 17. Angle of the plates larger than 90 degrees.

Fig. 18. Angle of the plates = 180 degrees.

The most delicate welding is that of pieces with re-entering angles. This is, however, seldom the case; but if such is the case it is better, if possible, to prepare the piece according to sketch 20 or 21, or, if any advantage results from it, according to sketch 22 or 23, a rigid rib being obtained which prevents deformations of the piece.

In general, in preparing plates to be assembled by oxacetylene welding care should be taken not to imitate shapes previously requiring bolting or riveting.

In the majority of cases oxacetylene welding does away with a lot of preparatory work; calking of edges, pulling apart of

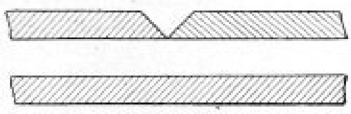


Fig. 18

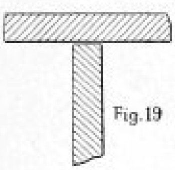


Fig. 19

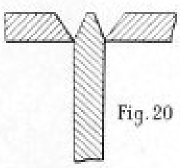


Fig. 20

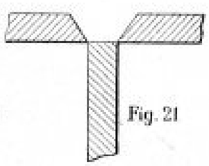


Fig. 21

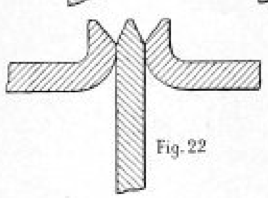


Fig. 22

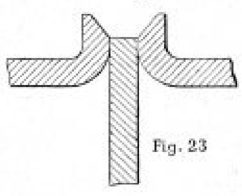


Fig. 23

rivets and other fastenings, operations always expensive and which are always to be avoided if possible.

Let us consider, for instance, the case of a cylindrical tank with riveted bottom and head. If this tank is not of a sufficient diameter, and is not provided with a manhole, it will be necessary to make it with at least a convex bottom or head. Anyway, its making requires a riveted cylindrical shell with two drawn heads at the ends to permit the riveting of bottom and head and calked edges

The same tank can be made by oxyacetylene process with solid welded heads.

We may remark, in passing, that oxacetylene welding has rendered possible the making (volume and resistance being equal) of tanks less cumbersome and lighter than those used before its advent, in that it has made possible the building of tanks with two convex bottoms without regard to the diameter and absolutely free of the double thickness of plates necessitated by riveted coverings.

Nearly all the tanks built to contain gases under pressure or very thin liquids, such as petroleum, are now welded by the oxyacetylene process, because aside from the advantages

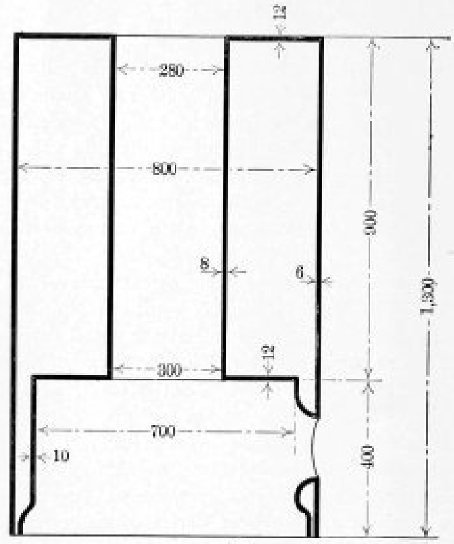


FIG. 24.

of weight, bulk and price which they have over the riveted tanks, they do not leak, a quality which is difficult to obtain by riveting, and even with subsequent tin soldering, particularly when these tanks are supposed to travel and are, consequently, subject to continual rough handling.

Aside from the saving which may be realized by oxyacetylene welding over riveting by doing away, in a large measure, with preparatory forge work, we must also consider the economy of this process of assembling in itself.

Let us, for instance, consider the case of the ordinary riveting together of two plates of ¼ inch.

1st. *Riveting (One Line of Rivets).*

Diameter of rivets, ½ inch; number of rivets per foot = 8.

Price paid to the workman per foot of joint:

Laying out the holes	$ .006
Marking	.0066
Drilling	.0294
Chamfering	.003
Riveting	.0192
Calking plates	.0048
Calking rivets	.012
Total	$0.0810

This cost of workmanship, obtained in a part of the country where the salaries are not very high, does not include the general expenses arising from the necessary power, keeping, etc., of the machinery and heating of the rivets.

Eight ½-inch rivets, 1.23 × 4 cents	$ .04
Workmanship (without general expenses)	0.08
Total cost of riveting per foot	$0.12

Oxyacetylene Soldering (Generator Acetylene).

Chamfering of edges, per foot			0.0108
Welding	acetylene	$0.0186	0.066
	oxygen	.0312	
	workmanship	.0162	
Total			$0.0768

This example shows conclusively that assemblage by oxyacetylene welding is more economical than by riveting. To complete our comparison we shall consider the case of the building of a vertical tubular boiler—shown in sketch No. 24—by oxyacetylene welding and by riveting. We shall not mention the operations, which are similar in both processes of manufacture: shearing and laying out of the plates, boring holes, assembling and expanding of tubes, etc.:

1st. *Oxyacetylene Welding (Generator).*

Chamfering of edges......	Shell, 8.5 ft. × $.0054		$ .046
	Furnace, 2.925 ft. × .0072		.021
	Uptake, 5.85 ft. × .066		.038
Welding...............	Shell, 4.225 ft. × .066		$ .278
	Furnace, 1.462 ft. × .21		.307
	Uptake, 2.925 ft. × .12		.351
Rounding and planing after welding..........			$ .60
Forging of furnace (uptake and mouth)........			2.40
Turning of circular plates..............			.40
Assembling of the boiler (mounter and help)......			.80
Welding 32.5 ft. @ $0.27..............			8.78
Total..................			$14.02

2d. *Riveting.*

Necessary plate:		
For shell..................	5.28 pounds	
For furnace..................	4.62 pounds	
For furnace flanges	9.90 pounds	
For flanges of the outer circumferential plates, 51.48, total 71.28 pounds, @ $0.25..............		$ 1.78
44 ½-inch rivets, 5 pounds; 275 ¾-inch rivets, 112 pounds, 117 pounds @ $.04..............		4.68
Marking rivet holes..............		1.40
Flanging the uptake with forge heat..........		1.00
Closing in on furnace boiler head flanges........		.80
Forging the furnace (uptake and mouth)........		4.00
Closing in the flanges of the plate	Inf., 105 pounds × $0.01	1.05
	Sup., 132 pounds × 0.009	1.19
Turning of circular plates..............		.60
Assembling the boiler..............		1.60
Riveting..............	5.5 ft. × $0.08..........	.44
	35.75 ft. × 0.117..........	4.18
Chipping and calking heads..............		1.60
Total..............		$23.32

The above prices of riveting are established on the supposition that the chamfering and calking are executed by compressed air (except for the heads, which require some hand work). They do not include the general expenses (material, coal and coke necessary for welding the charger and for the various forge work).

These results show the considerable saving obtained by judiciously using oxyacetylene welding in boiler making, and explain the development of this process as soon as it was known.*

The cost price may also be made much smaller by a preliminary warming up of the parts to be welded by means of the "Hauck" burner, using a less expensive combustible than the oxyacetylenic or oxhydric mixture. It is evident that in every instance where the method of manufacture, the shape of the pieces, the place where the work is to be done, will admit of such a warming up, a great advantage will result by such bringing of the parts to be welded to the highest practicable degree of heat; the more expensive combustible from the blow-pipe is thus used only to cause the actual welding, which the cheaper modes of heating cannot effect.

* These prices being those usual in French establishments must be proportionately increased for American plants.

TENSILE STRENGTH AND ELASTICITY OF PIECES WELDED BY THE OXYACETYLENE PROCESS.

The tensile strength of pieces welded by the oxyacetylene process is practically the same as that of the metal itself, and in general is rather superior.

On the other hand, the elasticity is to some extent reduced, which seems natural, the welded part having been melted and then rapidly cooled, whereas the adjoining parts have been obtained by fusion, followed by slow cooling or by laminating or hammering, which operations increase the malleability.

If after welding care is taken to anneal the piece, the elasticity is restored and becomes equal to that of the metal in the primitive state.

REPAIRS TO STEEL BOILERS.

In repairing in general, and particularly in repairing plates, the use of the blow-pipe is indispensable, because it very often happens that by its use pieces may be saved which otherwise

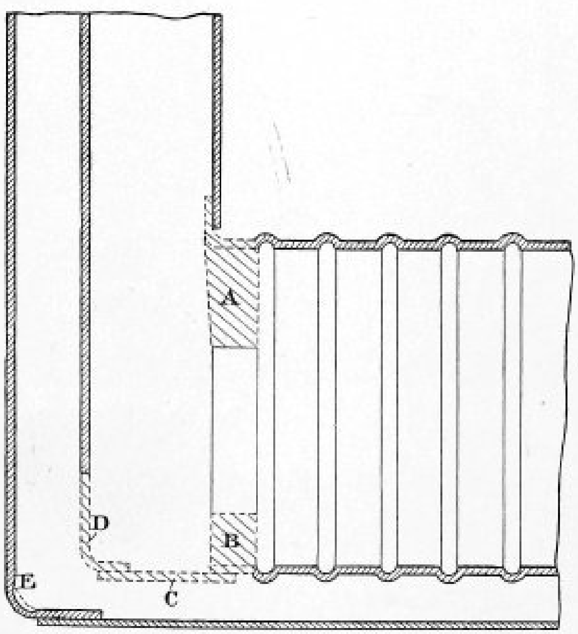


FIG. 25.

would have to be replaced; this fact alone results in considerable economy.

One of the interesting applications of the oxyacetylene process is the repairing of boilers. Nearly all the work of this class accomplished up to the present time has been done with dissolved acetylene, because portable tools are most convenient for this class of work, as they avoid unnecessary handling of heavy parts, and on the other hand the lower temperature of the oxyhydric mixture renders its application impossible in repairs where plates are above ½ inch thick.

For an example we will mention some of the very interesting work performed during the year 1906 by the use of dissolved acetylene by the Société l'Acétylène dessous du Sud-Est in the harbor of Marseilles.

1st. *Repairing Cracks Steamer "Eugene Pereire" of the French Line, March, 1906.*

The boiler furnaces of the mail steamer *Eugene Pereire* of the French Line had numerous horizontal cracks above the grate bars. There were about 100 of these, and in two of the furnaces they extended from end to end of the corrugations.

It had been attempted to stop the worst of these by plugging; but it would have been necessary to renew several furnaces, which would have detained the steamer for two months and caused great expense. All the cracks were wedged open with chisels and welded; all repaired parts were annealed with burners. In two spots where there were several adjoining cracks, a part of the furnace was cut out and replaced by a welded piece. No leak was observed at any of the 100 places so repaired at the hydrostatic or steam tests.

Only the sweating of a few drops, caused by trifling laminations, were discovered, and a little calking restored the water-tightness at such spots. The work lasted three weeks and cost $300. From the month of March of that year the steamer has been on the Algiers voyage, which is very trying for boilers on account of its shortness, the fires being banked and boiler temperatures changed so frequently. No trouble has been experienced with any of the welded parts.

was later replaced by a riveted patch. The welded part of this piece broke several times, but observations made in the case showed a defective quality in the plate to which the new piece was joined. The other fifteen held good. In the course of the work it was noted that the plates of the bottom of the boilers were badly eaten away at E on a space of about 36 inches; oxyacetylene welding was used to restore these plates to their original condition. In some spots they had been reduced by corrosion to a thickness varying between 1/8 and 1/16 inch.

3d. *Repairing Corroded Parts on the "Cholon."*

Oxyacetylene welding may be used to add metal directly to the surfaces of plates, to repair corroded spots, such as are frequently found in various parts of boilers. The flame of the

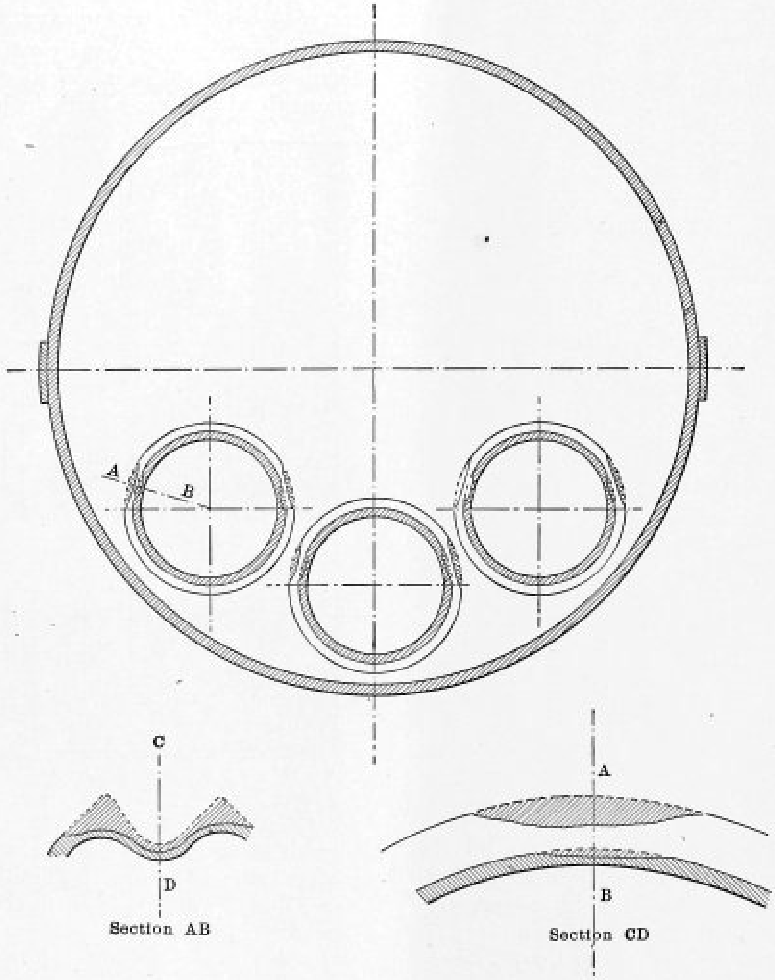


FIG. 26.

2d. *Assembling of Welded Pieces; Work on the "Marsa," June, 1906.*

The unreliability of riveted patches on damaged boilers is well known, particularly where the rivets are exposed to fire. The use of oxyacetylene welding, by which two pieces may be united end to end without butt straps, brings the plates to their original condition and avoids all the inconveniences of rivets. The work performed on the *Marsa* offers a remarkable example of the results that may be thus obtained.

Of the four furnaces of this steamer, the steel plates A and B riveted top and bottom to the fire-box, and the plates composing the back end of the combustion chamber, C *and* D, were completely worn out. Portions of these plates 18 inches to 36 inches long were cut out and replaced by welded pieces, as indicated in dotted lines on the sketch (Fig. 25.) This work was very successful, except on one of the sixteen pieces, which

blow-pipe is directed upon the plate, and when the latter begins to melt the workman presents to the flame a bar of soft steel about 7 by 7, which melts and fixes itself in drops on the corroded surface.

The repairs of the *Marsa*, already referred to, give a sample of the value of the welding process, but the work performed on the *Cholon*, of the Compagnie des Chargeurs Réunis, from Aug. 20 to Sept. 20, 1906, presents a still more striking case.

The eighteen corrugated furnaces of this steamer were badly eaten away on the surface. There was corrosion on each side and for some distance above the grate bars.

The work was difficult to perform, as the workmen were compelled to be inside of the boilers; and were inconvenienced by the heat of the blow-pipe flame; and the places to be welded were lower than the workmen's footing; 10,000 cubic feet of dissolved acetylene and as much of oxygen were used;

about 200 pounds of steel were used to cover the corrosions and restore the plates to their original thickness. This work, at a total cost of $2,400, avoided the replacing of eighteen furnaces, as originally ordered by the government inspectors.

4th. *Repairing Boiler Heads Worn by Corrosion or by Repeated Calking.*

A frequent fault in marine boilers is due to the grooving of the flanged furnaces riveted to the combustion chamber. These heads are under great stress on account of the expansion. Leaks, which are in some cases frequent, require calking; but each calking reduces the width of the collar or flange, and after a series of calkings the parts are practically worn out.

By the use of oxyacetylene welding such defects can be very easily repaired. An addition of material restores the plates to their original condition. The work is at times a lengthy one, but presents no special difficulty. Advantage is taken of a preliminary heating up to reshape, if necessary, the

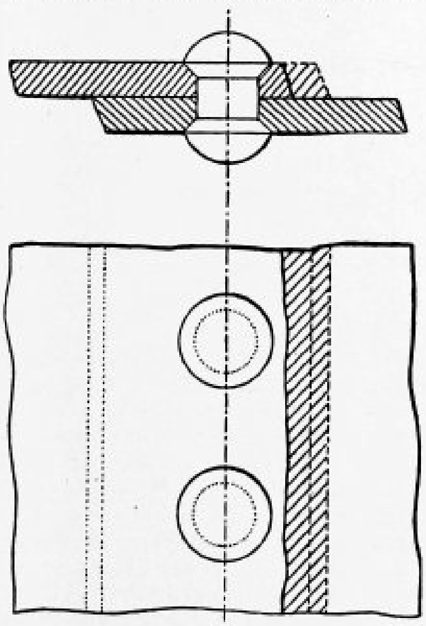


FIG. 27.

piece to be repaired, to insure its close contact with the plate to which it connects.

By making repairs as soon as a defect is noticed, boilers may be kept in perfect condition and last indefinitely; such repairs delaying the running schedule to an insignificant extent.

Railroad companies are by this process enabled to repair their locomotive boilers at trifling delay, and consequently to reduce considerably the capital otherwise tied up in repair shops.

Flanged Boiler Shells.

A somewhat unique form of boiler construction is used by one concern in England, the main feature of which is flanging the shell plates of the boiler instead of the heads. The illustrations show very clearly this form of construction. The boiler-shell plates are bent to shape in the ordinary way, and then the ends of the longitudinal seams are welded. The edge of the plate is then flanged over as shown in Fig. 1, by means of especially designed hydraulic flangers; afterwards the plates are placed in a large gas-fired furnace, where they are annealed in order to remove any internal stresses in the material.

In small boilers, when practicable, the ends of the boilers are each made in one piece, but in large boilers, where it is necessary to use two or more plates for the head, they are welded at the corners of the seam, as shown in Fig. 2, so as to form one flat circumferential surface for contact with the flanged shell of the plate; thus a broad bearing surface for making a secure joint is obtained similar to the jointing surface between a cylinder cover and a cylinder.

This construction enables the rivets holding the end plates to the shell to be placed longitudinally in relation to the

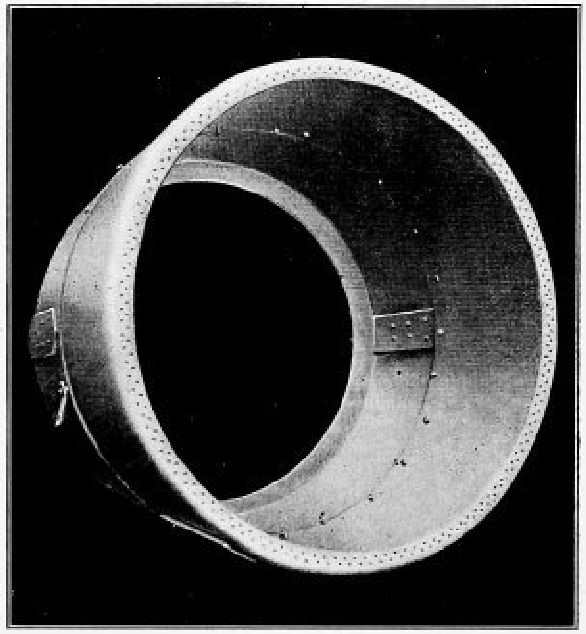


FIG. 1.

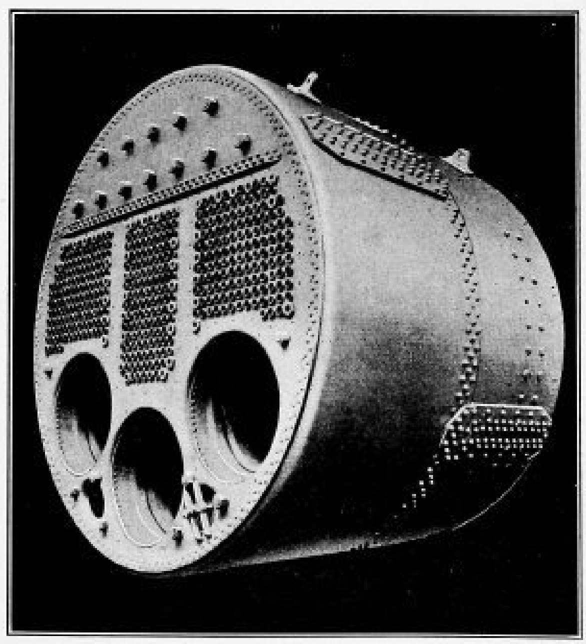


FIG. 2.

center line of the boiler; thus any pressure inside the boiler places the rivets under a direct tensile stress, and they are in the best position to resist the "work" of the plates, due to the constant expansion and contraction of the boiler when under steam. Another advantage obtained from the position of the rivets is the absence of rivets under the bottom of the shell. While this style of construction can be used for any type of stationary or marine fire-tube boiler, yet it is most frequently applied to Scotch marine boilers.

Approximate Method of Developing a Sloping Fire-Box Wrapper Sheet.

In many types of locomotive boilers, the fire-box wrapper sheet is considerably higher at the flue-sheet end than at the door-sheet end. In Figs. 1 and 2 are shown the end and side elevations of a fire-box wrapper sheet of this shape; Fig. 1 representing an outline of both ends of the wrapper sheet, and Fig. 2 representing a side view of the sheet.

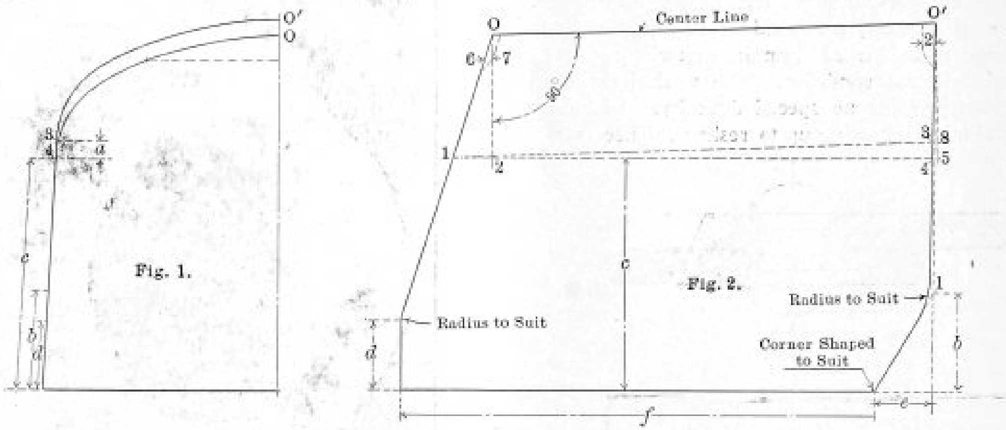
At the very outset let it be understood that for developing work of this character, triangulation is the best and safest rule, yet with this particular shape of fire-box, the wrapper sheet may be developed satisfactorily by an approximate rule, which will be described.

First, draw up the outline of the respective views as shown in Figs. 1 and 2. In Fig. 1 the points 3 and 4 represent the points of intersection of the crown sheet with the side sheet at the front and back ends respectively. Irrespective of the fact that the fire-box may be in one sheet, the curved part, Fig. 1, known as the crown sheet, and the straight part, or distance *c*, as the side sheet. It will be understood that all following remarks in describing the layout will refer to the parts of the sheet as outlined.

Extending horizontal lines from the points 3 and 4 in Fig. 1 to Fig. 2 gives points 1, 3 and 4 in Fig. 2. Now draw connecting lines between points 1 and 3, 1 and 4. This gives the true lengths of lines between the points, and since the center line from *O* and *O'* is its true length, it will be seen that we have obtained the true length of three lines.

To develop the pattern, Fig. 3, draw the center line from *O* to *O'* equal to the length of center line in side elevation, Fig. 2. Make the radius *AA*, Fig. 3, equal in length to the distance from *O'* to 3, or *O'* to 4 in Fig. 1, and then using *O* and *O'*, Fig. 3, as center points, draw arcs as shown. Draw at right angles to *O O*, Fig. 2, the line *O* 2, then make the radius *BB*, Fig. 3, equal in length to the distance from 1 to 2, Fig. 2, and using point 2, Fig. 3, as a center point, draw arcs intersecting the arcs previously drawn, thus locating point 1.

Make the radius *AD*, Fig. 3, equal in length to the distance between 1 and 3, Fig. 2, and using point 1, Fig. 3, as a center, draw an arc locating point 3. With radius *AC* made equal to distance *a*, Fig. 1, and point 3, Fig. 3, as a center, draw an arc. Then make the radius *AE*, Fig. 3, equal to the distance



OUTLINE OF FIRE-BOX WRAPPER SHEET.

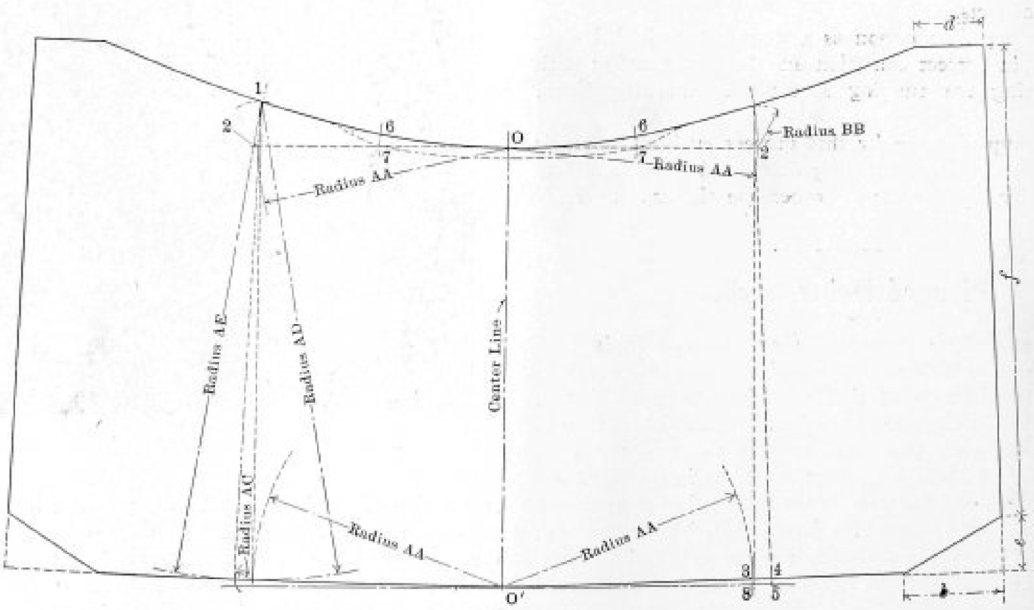


FIG. 3.—LAYOUT OF FIRE-BOX WRAPPER SHEET.

between the points 1 and 4, Fig. 2, and using point 1, Fig. 3, as a center, draw an arc intersecting the arc previously drawn, locating point 5. Thus the vital points of the crown sheet have been developed.

It will be seen that if a line is drawn at right angles to the center line at point O', Fig. 3, the distances between points 3 and 8, and points 4 and 5, are equal to corresponding distances in Fig. 2.

The camber line can ordinarily be placed in by holding a flexible stick on the points 1, O and 1 on the door-sheet end, and on the points 3, O' and 3, on the flue-sheet end, but it is advisable, particularly at the door-sheet end, to locate some intermediate points, hence an intermediate point about midway between O and 4, Fig. 1, is located. From this point extend over to Fig. 2, a horizontal line, locating points 6 and 7. Then set off on the horizontal line, Fig. 3, between points O and 2, a distance equal to that set off on the curved line Fig. 1. The distance between 6 and 7, Fig. 3, is made equal to that between 6 and 7, Fig. 2. Any number of like intersecting points can thus be located, but since the above demonstrates thoroughly the principle, no further demonstration is necessary.

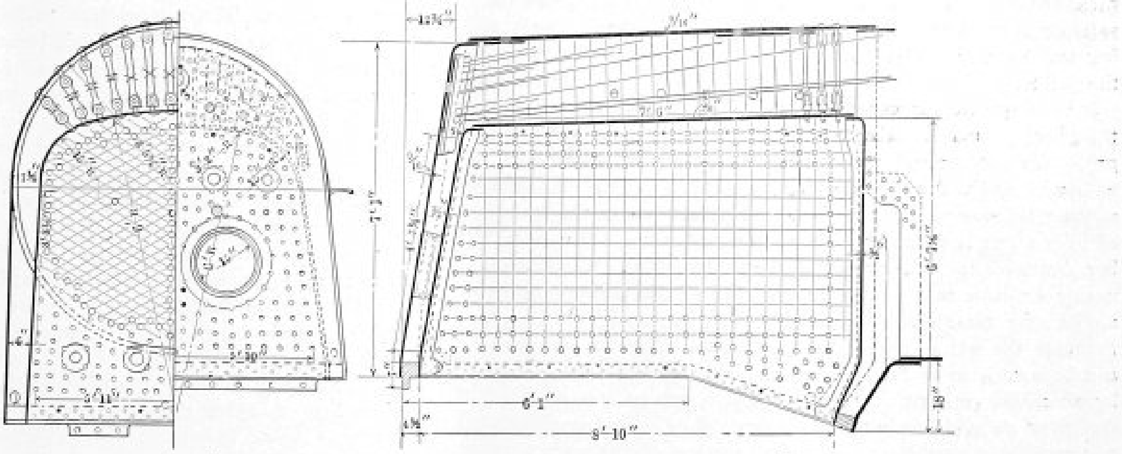


FIG. 4.—DETAILS OF FIRE-BOX, LAYOUT OF WHICH IS SHOWN IN FIG. 3.

To develop the side sheet is only to reproduce what is shown in the side elevation, Fig. 2, with the exception, however, that the vertical distances *b*, *c* and *d*, Fig. 2, should be taken from the end elevation, Fig. 1, so as to obtain their respective true lengths.

Of late years, some builders are putting an extended flange on the door and flue sheets, cutting the length of the crown sheet as indicated by the dotted line in Fig. 2. When such is the case the crown sheet is laid out as shown by dotted line, Fig. 3, the distance being determined at the option of the builder.

Tests of Riveted Joints.

With the present requirements of large members for nearly every line of steel construction, it becomes of the utmost importance to reinvestigate the fundamental principles governing such construction before they are applied to members of much greater dimensions. The results obtained in the past by loading comparatively small members to failure, although in some cases few in number, have formed in reality the entire empirical basis of structural design. They have been of the highest value, and, in general, it may be considered both rational and safe to reason from the tests of small members to the design of the largest now required, but that is not by any means the whole subject, even if the apprehensions created by the Quebec bridge failure be disregarded. The *Engineering Record* has already commented editorially upon the need of tests of the largest steel compression members which can be broken in any testing machine now existing, and all observations of that character applicable to compression members bear no less forcibly on riveted joints.

On the whole, a good many riveted joints which may be considered full size have been tested to destruction, the most of such investigation having been done at the Watertown arsenal. This work, however, was performed a dozen or fifteen years ago before riveted joints had assumed anything like the magnitude in structural work which they now attain. A reference to the records of these and other similar tests will show at a glance the pressing need of an extension of that class of experimental work to joints of more nearly the proportions constantly employed in structural design of the present day. The plates then used were, in the main, much thinner than those now required, and the prevailing diameter of rivets now employed is seldom found in the older tests. Anyone who has had occasion to test plates and shapes of light section will be impressed by the need of tests of joints built of much heavier plates than those of the old investigations and with the further need of using, not only larger rivets to correspond with those now generally used in heavy work, but also greater numbers in the joints to be investigated. With joints of one or two rows of rivets, whether that joint be butt, lap or any other type, the distribution of the shearing stresses on the rivets or the tensile stresses in the net sections of the plates must be at least approximately uniform, eliminating any strong probability that the maximum intensity of either kind will be substantially different from the mean. That condition no longer holds, however, with three or four or more rows of rivets, which may easily be required in a structural tension joint, to say nothing of the excessive grouping of rivets found in compression joints, and allowing for the fact that the latter are usually supposedly of such a character as to permit the machined ends of plates and shapes to abut. Finally, the thicker plates produce a proportionately greater bending of the rivets. This latter is a most important consideration, for its influence in reducing the ultimate resistance of the joint is too complicated to permit its value to be computed with any sensible degree of accuracy.

The thinner plates not only leave the rolls at a sensibly lower temperature than thick plates, but they also generally have more work put upon them between the ingot and the final pass between the rolls, both of these effects tending to increase greatly the elastic limit and to some extent the ultimate resistance. A similar general observation, although of less force, may be applied to the smaller rivet in comparison with the larger. These and other material considerations go to show conclusively that while the values determined by the older tests of joints may not be, and probably are not, dangerously in error when applied to the heaviest connections now in use, there is sufficient reason to believe that either new values should be determined or the older confirmed by sufficient range of experimental work to include the full-size types now generally employed.

Public interest, at least that portion of it with industrial or technical affiliations, has been much stimulated during the past year or two by agitations designed to secure Federal appropriations or funds from other quarters to be expended in full-size tests of structural members. No work of this character can be considered satisfactorily comprehensive without including the breaking of full-size riveted joints with such complete records of attendant phenomena as to solve all questions relating to the intensities and distribution of the tensile, shearing and bearing stresses developed in the various elements of the joints.

It is of special importance, among other things, to determine the effect of such unbalanced riveted connections as that of a group of rivets through the long leg of an unequal legged angle, both with and without connecting lugs, and what may be taken as the real net section in such cases and others where the group of joint rivets is symmetrical about the center line of the member, but with the outer rows of rivets diminishing in number nearly or quite to a point. In the case of the tension flange angles of a plate girder, when the rivets are staggered so as to make the net section the greatest practicable, no designer can be certain as to the value of that net section. Practice is by no means uniform in regard to these various questions of design of riveted connections, although they are of great importance as constituting the main features of the particular constructions in question. It is not possible to solve these questions of unsymmetrical arrangements of rivets or of real net sections except by full-size tests with the dimensions corresponding closely to those of actual work.

As already indicated, the apparent shear of rivets in joints, as determined by test, would naturally be expected to be sensibly different from the ultimate shearing stress as determined for pure shear. The rivet has been upset to fill its hole in the process of heading, but, what is of more consequence, it is usually subjected to much bending unless the plate is thin. There are at the present time not enough data to determine what may properly be taken as the working shear, with accuracy, in this branch of structural design. It is known well enough that when the rivet is subjected to heavy bending, its resistance to apparent shear is materially less than when such bending is absent, but a suitable allowance for thick plates has not yet been determined. Nor, again, can any engineer be confident of the value of rivets which bind three or four or more cover plates to the flange angles of a plate girder, supposing that the rivets fully fill their holes. Although riveted joints are constantly designed as if every element of any given case were completely known, few parts of a steel structure are in greater need of thorough experimental investigaton.—*Engineering Record.*

Trials of briquettes of bituminous coal have been made by the United States Navy at Norfolk, Va., the results showing that the briquettes gave better results as steam raisers on the torpedo boats than raw coal.

W. H. S. BATEMAN, Philadelphia representative of the Champion Rivet Company, of Cleveland, Ohio, has recently made arrangements to represent also the Parkesburg Iron Company, of Parkesburg, Pa., as sales agent throughout the East and South, for the Parkesburg charcoal iron boiler tubes and skelp. Mr. Bateman's headquarters are at Room No. 822, Arcade Building, Fifteenth and Market Sts., Philadelphia, Pa.

Combustion Processes in English Locomotive Fire-Boxes.*

BY DR. F. J. BRISLEE.

Ever since the signal triumph of Stephenson's "Rocket" at the Rainhill trials in 1829, the exhaust steam from the cylinders has been utilized for increasing the draft in the fire-box. The employment of the "steam-blast" for accelerating combustion, so as to render the rapid production of steam possible, has been universal so far as locomotives are concerned, but in the majority of other boilers the steam-blast has been replaced by some form of forced or induced draft by means of a fan. The employment of the steam-blast on the locomotive, where space is limited, has the great advantage of simplicity, although, on account of its intermittent character and its dependence upon speed, etc., it leaves much to be desired as a means of supplying air to the fire-box. Many investigations of the efficiency of combustion taking place in stationary, marine or other boilers, under both natural and forced draft, have been made; but few, if any, have been made upon the products of combustion of locomotives during actual running, although the charge of emitting poisonous gases was made against the locomotive practically at the time of its first successful introduction.

The following investigation was undertaken for the purpose of determining—

(1) The efficiency of the combustion of the fuel.

(2) The loss of carbon due to the production (or loss) of carbon monoxide.

(3) The variation of the products of combustion due to variations in the demands made upon the engine. *e. g.*, weight of train drawn, speed, gradient.

(4) Whether chemical equilibrium conditions corresponding to the fire-box temperature are ever attained.

(5) The variation of the products of combustion with the depth of fire.

Two locomotives were employed in this investigation which differed in size of fire-box, especially as regards depth, size of boiler and diameter of driving wheels. The first experiments were made upon a London & North-Western Railway locomotive of the "Precursor" class, first introduced in 1904, and the second series upon a London & North-Western Railway locomotive of the "Experiment" class, which came out in 1905. These two locomotives differ in size and depth of fire-box, the fire-box of the "Experiment" class being considerably larger than that of the "Precursor" class, and only about one-half as deep; hence the effect of working with a thinner fire will be seen from the analysis of the products of combustion. Figs. 1 and 2 show sections of the fire-boxes of these two classes of locomotive, together with the leading dimensions.

The first point investigated was the variation of the products of combustion with varying speeds, weight of train drawn and gradients. The result showed that the loss due to the formation and escape of carbon monoxide is greatest at comparatively low speeds, with late cut-off and strong blasts at long intervals, as compared with much shorter intervals when running at high speeds, and at speeds of about 60 miles an hour, the quantity of carbon monoxide in the products of combustion is practically nil. Further, in most cases, there was more than sufficient oxygen present to burn the carbon monoxide completely, and the escape of this from complete combustion is due, in all probability, to the extremely rapid rate at which the gases are swept through the tubes and cooled down, so that the oxygen and carbon monoxide had no

* From a paper presented before the British Institution of Mechanical Engineers.

time to combine. The presence of carbon monoxide in the products of combustion at the low speeds is due to the intermittent character of the air supply. The escape of the exhaust steam up the funnel takes place in a series of "puffs," and the interval between each "puff" varies with the speed of the train, hence the products of combustion are left in contact with the strongly-heated fuel for a time interval depending upon the rapidity with which the "puffs" follow each other, and so partial reduction of the carbon-dioxide to monoxide takes place. Then, at the next "puff" the gases are drawn out of the fire-box, along the fire-tubes and into the smoke-box before the complete combustion of the carbon monoxide has time to take place. The effect of the gradient is that of reducing the speed of the train, thereby increasing the length of time between each "puff"; hence the time during which the products of combustion remain in contact with the incandescent fuel is also increased. The heavier the train, the greater is this slowing down when ascending a gradient; hence the proportion of carbon monoxide which escapes combustion is greatest when the engine is working heavily, *e. g.*, drawing a heavy train up a steep gradient.

The vacuum in the smoke-box was next measured. The firts measurements showed that it varied with the time of cut-off by the slide-valve, as well as with the extent to which the regulator (throttle) was opened. It depended also upon the resistance of the fire to the passage of the air. The vacuum reached, under certain conditions, was 10 to 12 inches of water, but on the average it was 5 to 7 inches of water, the highest figures being only very occasionally reached, and were never steady, and were not maintained for more than a few minutes. When the fire-door was opened for firing, the vacuum sank from 5 or 7 inches to 1 or 2 inches, the air entering freely through the open fire-door. At high speeds the vacuum was smaller, as a rule about 3 to 5 inches, but steady, and then the air supply approximated to a steady current, and combustion was complete, the amount of carbon monoxide being very small, or nil.

The results indicate that the most efficient combustion takes place when the vacuum is relatively small and the speed

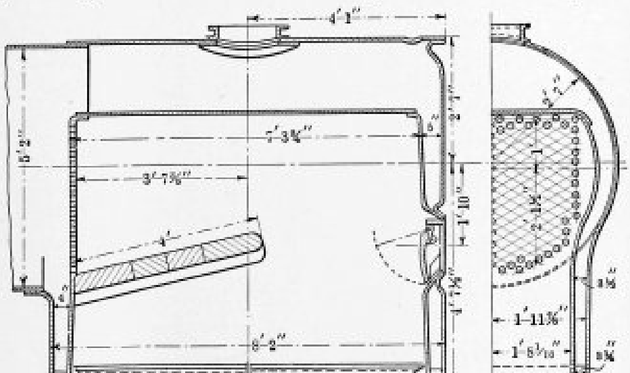


FIG. 1.—FIRE-BOX "EXPERIMENT" CLASS.

high. The higher vacua were never steady, but were obtained in a series of jerks. The conditions necessary for the most effective combustion require that the current of air supplied to the fire should be a steady current, and the amount sufficient to render the velocity of combustion great enough for the production of the necessary steam. The employment of the exhaust steam to induce the air supply is only efficient at high speeds, when the "puffs" follow in extremely rapid succession, so maintaining a steady, partial vacuum in the smoke-box, while the air is pushed in through the ashpan dampers, and thence through the fire, at a moderately high and fairly constant pressure, due to the passage of the engine through the air. When the thickness of the fire is considerable and the air supply is intermittent, as when the steam-blast is employed and at low speeds, the tendency for the carbon dioxide to be reduced to carbon monoxide is greatly increased; hence *a priori* one would expect a much smaller loss of carbon, due to the formation of carbon monoxide, in an engine with a thin fire than in one having a deep fire. This point was next investigated. The engine employed was a London & North-Western Railway locomotive of the "Experiment" class. In this class of locomotive the fire-box is only about one-half as deep as in the "Precursor" class, but considerably larger in other directions.

The runs selected were nearly all on the Carlisle route, and include all the heaviest, long, non-stop runs on the London &

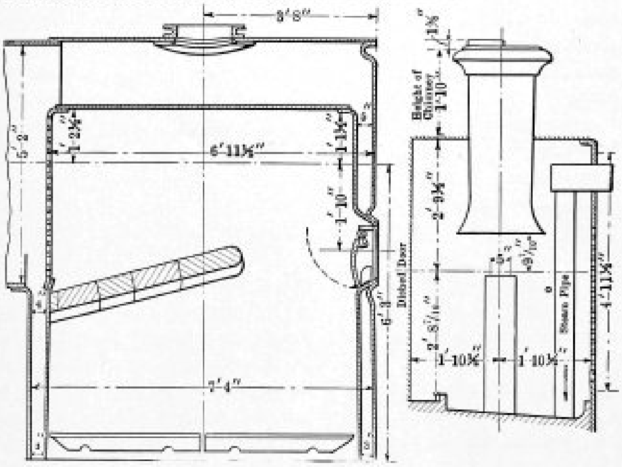


FIG. 2.—FIRE-BOX AND FRONT END "PRECURSOR" CLASS.

North-Western Railway system. The loads taken were, as a rule, very heavy and the average speeds high. Further, this class of engine was specially designed with a view to working heavy passenger traffic on the London to Carlisle route. The road from Crewe to Carlisle is especially heavy, the gradients being all fairly steep, the track being almost continually uphill from Preston to Shap Summit. The first run was from Liverpool to Shrewsbury and back, in which the load was by no means heavy and the speed high.

The percentage of carbon monoxide is not so high with the "Experiment" class as with the "Precursor" class. The partial vacuum in the smoke-box is also much less in the "Experiment" class than in the "Precursor" class, due to the decreased thickness of the fire, which offered less resistance to the passage of the air and also to the increase in area of the grate. The vacuum in the smoke-box in this class was about 3 to 5 inches of water, higher figures only being very occasionally reached.

The next runs were all on the Crewe to Carlisle route, and the results show a very great diminution in the percentage of carbon monoxide. Even in the highest it is less than 2.0 percent, while the carbon dioxide, in the majority of instances, is high. The "gas-producer" action of the fire-box, resulting in the partial reduction of the carbon dioxide to monoxide is very greatly reduced, as the results show, by reducing the depth of the fire. The effects of heavy working when the full pressure of the boiler is on the cylinders, and the induced draft fierce and intermittent, are especially noticeable. This train was practically the very heaviest train running on the system, and demanded the full power of the engine. The rapid passage of the air through the thinner fire resulted in holes being made in the fire by the "jerky" steam-blast, and consequently a large amount of air was drawn through the fire, which had no time to come into contact with the fuel, owing to the rapidity of its passage. The passage of so large an amount of excess air resulted in a considerable lowering of the temperature.

Comparing the results for the "Experiment" with those for the "Precursor" class, the advantage of employing a thinner fire is manifest, so far as efficient combustion is concerned. At the same time, it is evident that a greater amount of judgment in firing is required in order to prevent the fire breaking into holes and an unduly large excess of air being drawn through the fire, thereby reducing the temperature, and seriously impairing the steam-raising power of the engine. The presence of the carbon monoxide in the products of combustion, together with excess oxygen, may be due to either the cooling of the gases before the combustion was complete, or to incomplete mixing.

Considering all the drawbacks of the method of supplying the air to the fire-box, the results for both classes of engines show a very great efficiency, and compare very well with stationary and marine boilers employing either natural or forced draft. The above results only take account of the carbon lost as carbon monoxide, the other means of loss of fuel are:

(1) Loss of carbon as smoke.

(2) Loss of unburnt hydrocarbons.

(3) Loss of solid fuel as fragments thrown out by the steam-blast.

At the stage of the combustion when the samples were taken, that is, after the smoke had cleared, the amount of unburnt hydrocarbons was nil, only very slight traces being found in the samples. The loss of carbon as smoke was not excessive, as comparatively little smoke is emitted by a locomotive when running. The loss of solid fuel thrown out by the steam-blast through the funnel is extremely difficult of estimation, but is considerable in amount. The heat carried off in the products of combustion is another source of loss of fuel, but one of the most difficult of remedy in a locomotive, where space is limited, and where increase of weight beyond certain limits is undesirable.

The results of the investigation represent the combustion taking place in first-class locomotive practice and on express trains of high average speeds. The loss due to the formation and escape of carbon monoxide must necessarily be greater with low-speed trains, owing to the intermittent character of the air supply.

Why Do Staybolts Break More Frequently on the Left Side? *

Your committee has advised with a number of general foremen and foremen of boiler shops, whom it was possible to visit personally, and have taken the matter up by letter with others. The general conclusion from the data obtainable is that there is no reason, so far as can be learned, why stay-bolts should break on the left side of the locomotive fire-box any oftener than upon the right side. It has been suggested that the practice of using the injector on the left side almost exclusively, that obtains on some roads, might explain in some cases why the condition suggested by our subject might prevail. This, of course, would be the result of the widely varying temperatures and resulting stresses set up in the steel brought about by the frequent injection of cold feed water. It is clear, of course, that the flow of the cold feed water is downward from the point of injection, and then backward along the barrel and around the bottom section of the mud-ring. However, it must be said that this reasoning is not conclusive, as the data obtained fail to substantiate the proof. We feel that there is no need of considering in this connection what conditions might result from the use of an inferior supply of stay-bolt iron, or from side sheets that might have accidentally passed inspection. In other words, it is not within the province of this report to consider matters which might be classed as constructive accidents.

A record of the number of broken stay-bolts on twenty-three 100-ton engines shows that for a certain period of time a total of 622 stay-bolts were broken on the life side, while 628 were broken on the right side, making an excess of the right side over the left side of six. Again, a three months' record of broken stay-bolts on eight locomotives at the Urbana shops of the Cleveland, Cincinnati, Chicago & St. Louis Railway, Peoria and Eastern division, shows that a total of only forty-six bolts were broken on the left side, as against eighty-one on the right side, making an excess of the right side over the left side of thirty-five.

With the data in hand, the inevitable conclusion is that there is no scientific reason why stay-bolts should break more often on the left side of the fire-box than on the right side, and, further, that such a condition is not borne out by facts.

* From a report presented by A. Bradford and W. H. Clough at the General Foreman's Convention.

Pressure Tanks.

BY N. A. CARLE.

The capacity of pressure tanks is usually given in gallons, and it is necessary to determine the proper diameter, length of tank and the thickness of plate required. The usual sizes range from 18 to 72 inches diameter and from 5 to 15 feet in length, designed for working pressures of from 75 to 200 pounds per square inch. The ratio of diameter to length usually varies between 1 to 3 and 1 to 5.

The thickness of plate depends upon the diameter of the tank, the working pressure, the efficiency of the riveted joint and the factor of safety desired. These quantities are independent of each other, although it is found to be good practice to have a certain relation between the *kind* of riveted joint and the working pressure. With these determined and a factor of safety selected, the thickness of the plate will vary with the diameter of the tank. It is, therefore, essential in designing a tank to get as small a diameter as will give a length consistent with the clearances available. The heads of tanks are usually dished and flanged, in stock sizes, in multiples of 6 inches, so that it is desirable to select one of these sizes in designing the tank.

The chart in page 241 is designed to determine directly the diameter and length of tank for any specified capacity up to 1,500 gallons, and the thickness of plate to be used for such a tank under working pressures of from 75 to 200 pounds, with a factor of safety from 3 to 8, using joint efficiencies from 45 to 90 percent. The efficiencies of joints vary only slightly in the practice of the various boiler shops. This is due to the requirements of the insurance companies giving a uniformity to the type and efficiency of the joints for different pressures and thicknesses of metal. The standard generally accepted is that of the Hartford Steam Boiler Insurance Company's specifications. The type of joint for the different efficiencies for Hartford specifications has been indicated on the chart.

EXAMPLE.

What thickness of plate should be used in designing a 1,400-gallon tank for a working pressure of 100 pounds per square inch, with a factor of safety of 5?

Starting with 1,400 gallons, and selecting the smallest diameter shown on the chart, it is found that a 48-inch diameter 15-foot tank will give the desired capacity. For 100 pounds working pressure use a double lap-riveted joint with an efficiency of 65 percent. Then, starting with a 48-inch "Diameter," read across to 100 pounds "Working Pressure," then down to 65 percent "Efficiency of Joint," then over to 5, "Factor Safety," and down to 5/16 inch "Thickness of Plate."—*Power*.

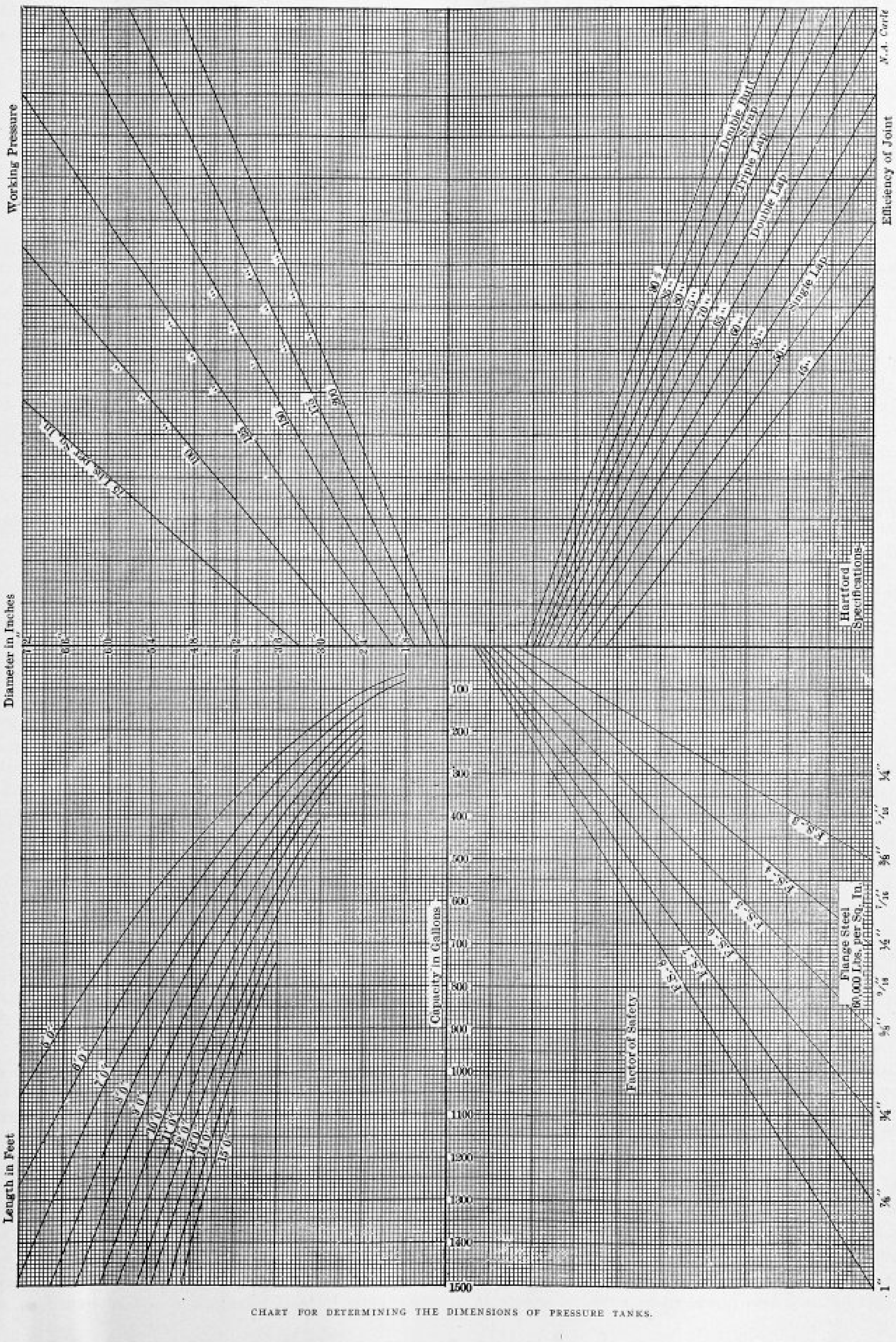


CHART FOR DETERMINING THE DIMENSIONS OF PRESSURE TANKS.

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.

The edition of this issue of The Boiler Maker comprises 7,000 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

The Quality of Boiler Plate.

In spite of the amount of time and money spent by members of the American Boiler Manufacturers' Association in effecting an agreement with the American Association of Steel Manufacturers, regarding standard specifications for the quality of boiler plate, we find that the latest development in State law, governing the quality of material and construction in boilers—that is, the Massachusetts law—allows material to be used which is of a quality inferior to that prescribed in the specifications of the American Boiler Manufacturers' Association. The Massachusetts Board of Boiler Rules adopted as their standard specifications for boiler plate those prescribed by the steel manufacturers in 1901. These specifications were amended by the steel manufacturers on Feb. 6, 1903, so that the percentage of phosphorus allowed in flange or boiler steel was reduced from .05 percent to .04. On Jan. 20, 1906, the steel manufacturers adopted resolutions agreeing to the specifications of the Boiler Manufacturers' Association, but resolved at the same time that it was desirable to still maintain their standard specifications as revised in February, 1903, as a basis for the general trade. The main difference between the steel manufacturers' specifications and those of the boiler manufacturers is in the percentage of phosphorus and sulphur allowed. The steel manufacturers' specifications admit of .04 percent sulphur in all three grades of boiler steel, while the boiler manufacturers' specifications place the limit of sulphur in flange or boiler steel at .04 percent, in fire-box steel at .035 percent, and in extra soft steel at .035 percent. The steel manufacturers' specifications allow .06 percent of phosphorus in flange or boiler steel and .04 percent of phosphorus in fire-box and extra soft steel, while the boiler manufacturers' specifications limit the percentage of phosphorus in flange or boiler steel made by the acid process to .06 percent, and in that made by the basic process to .04 percent, while in both fire-box and extra soft steel the limit is .035 percent. Thus the Massachusetts laws allow .01 percent more sulphur in each grade of boiler steel and .01 percent more phosphorus in acid fire-box steel and .01 percent more phosphorus in extra soft steel than is allowed by the boiler manufacturers.

That the boiler manufacturers' specifications regarding the amounts of sulphur and phosphorus allowed in the material are not excessively severe, is shown by the fact that out of 599 tests made during one year on boiler plate the highest phosphorus was .031 percent, the lowest .007 percent and the average .016 percent, while the sulphur ran from .036 percent down to .013 percent, with an average of .024 percent. In view of the fact that so many tests show a percentage of both phosphorus and sulphur below the limits specified by the boiler manufacturers, it seems hardly possible that there would be much trouble in obtaining satisfactory material if the standard specifications for the general trade were raised to correspond with those prescribed by the Boiler Manufacturers' Association.

A Pointer for Contributors.

We find that many men who are capable of sending us valuable editorial matter have hesitated to do so because they were skeptical of their ability to write a readable article and to make a presentable drawing. Naturally, no one would care to have an article published in which his ideas were not clearly expressed, and the illustrations for which showed a lack of skill in drafting. For the benefit of these men we wish to explain briefly our method of working up such contributions. It is very seldom that drawings are published exactly as we receive them, except in the case of blue prints, which are the work of expert draftsmen. Where it is necessary we make a careful drawing and have the engraving made by a process in which all the figures and letters are stamped. In this way we are able to use a very rough or crude pencil sketch which is not even drawn to scale, and publish the drawing complete as far as it is possible for an expert draftsman to make it. As far as the text goes, we seldom expect a busy man to sit down and write a carefully worded article. All we need and expect are the facts expressed as clearly as possible from which in nine cases out of ten the article is completely rewritten. In case the author desires to see the article after it has been edited in this way, we are perfectly willing to submit a proof before going to press. We trust that this short explanation will give many the necessary courage to submit articles on practical subjects, which only the man in the shop, can thoroughly appreciate. Such articles are valued not on account of the literary ability of the writer or his skill as a draftsman, but on account of the practical knowledge which they contain, which may be of help to some one else in the trade.

TECHNICAL PUBLICATION.

Massen-Distillation von Wasser. By Ludwig Bothas. Size, 5½ by 8¾ inches. Pages, 53. Figures, 8. Berlin, 1908: Julius Springer. Price, 2 marks.

This little work is divided into five sections, covering respectively the different methods of cleansing water; the construction and operation of water distilling plants; the conversion of distilled water to railroad service; the drinking water distilling plant of Baku; and an appendix giving a bibliography of distilling plants and a number of illustrations.

The subject is taken up from the points of view of filtration, sterilization, distillation and chemical cleaning, and is based largely on Russian practice, the author being one of the government public works officers in St. Petersburg. In the specific case of the description of the plant at Baku, a population of 200,000 inhabitants is supplied with good drinking water in a portion of Russia where atmospheric precipitation is rare, and rivers and good springs in the neighborhood are entirely lacking. This has made it necessary to make use of water which, without treatment, would be totally unfit for drinking, and the results are said to have been entirely satisfactory with regard both to the chemical composition of the water as altered, and its adaptability to household uses.

PERSONAL.

JAMES J. FLETCHER, second vice-president of the International Master Boiler Makers' Association, has accepted a position as superintendent of the boiler department of the Manitowoc Dry Dock Company, Manitowoc, Wis.

L. BORNEMAN has been made general foreman boiler maker of the Chicago, St. Paul, Minneapolis & Omaha, in charge of the boiler shops of the entire system, with headquarters at St. Paul, Minn.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—How do you patch a cracked flue sheet where the crack runs about 14 inches long in the flange of the sheet? A. C.

A.—The first operation would be to cut out the patch. In so doing be sure to cut out all the defective parts. If the sheet is cracked it would be well to cut out an inch or two more at each end, so as to be sure to remove all the defective parts before applying the patch; for in a good many cases the fracture extends further into the sheet than can be seen with a magnifying glass. The next operation would be to lay out the patch, flange and fit same by the following method: Put a few holes in the flange of the patch, also the stay-bolt holes, then bolt the patch in position and heat it with an oil heater, so as to lay up the corners, etc. Mark the holes in the flange of the patch if possible; if not, lay them out, taking the dimensions from the old piece. If the patch is located where all the holes can be marked off on same, then all the holes can be layed out and drilled in the flue sheet before the patch is applied for fitting, but if the holes cannot be marked off from the flue sheet it will then be necessary to lay out the holes in the patch first, and mark them on the flue sheet, which can be done by marking around the patch on the flue sheet before it is removed after being fitted. This line will show how much material is to be removed from the patch and will locate the line for the holes. The best method when possible is to mark around the patch through the stay-bolt holes in the outside throat sheet. This line would be more accurate for locating the rivet line than the first method. If the patch is to be applied with patch bolts, it is good practice to punch the holes in the patch the same size as the drill to be used for the patch bolts. Then bolt the patch in position and drill through the holes, then remove the patch and ream and countersink the holes to suit the patch bolts. Only a short lap should be allowed on patches in the fire-box, especially for the inside lap, as the outside lap can be chipped off at any time. My practice is to allow 1/16 inch less than the rivet diameter from the center of the hole for the inside lap.

It is a common practice in some shops to put 1/32-inch thick asbestos paper under patches in the fire-box, which gives very good results in bad water districts. G. W. BENNETT.

Q.—How do you find the length of an arc, knowing the diameter of the circle and the number of degrees in the arc? In Fig. 2, what would be the length of the arc B if arc A is 40 inches long and the radii for A and B, respectively, are 30⅜ inches and 30 inches? J. B. R.

A.—To find the length of the arc of a circle, given the diameter and the number of degrees in the arc, multiply the diameter by the number of degrees and multiply this result by

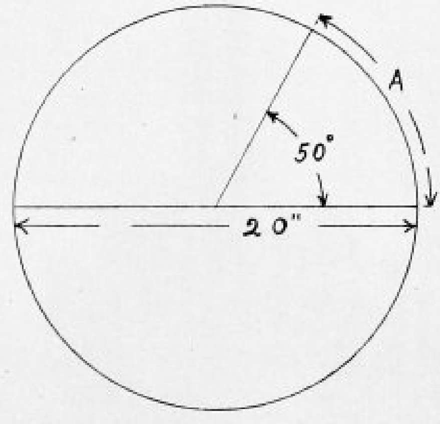


FIG. 1.

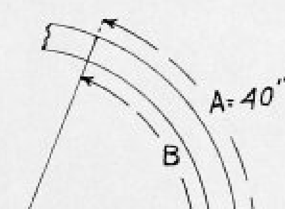


FIG. 2.

.0087266; for instance, in the circle shown in Fig. 1, the length of the arc *A*, which contains 50 degrees, is equal to $50 \times 20 \times .0087266 = 8.7266$. The length of the arc *B*, in Fig. 2, is to the length of the arc *A* as the radius of the inner circle is to the radius of the outer circle; that is,

$$\frac{B}{40} = \frac{30}{30\frac{3}{8}}$$

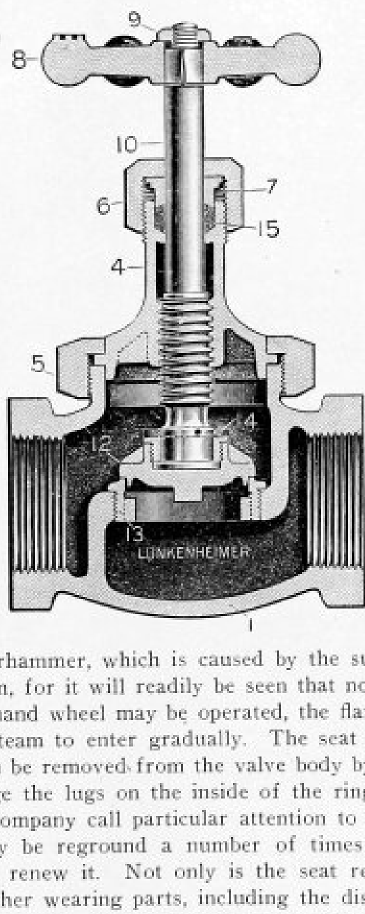
$$B = \frac{30 \times 40}{30.375}$$

$$B \doteq 39.51 \text{ inches.}$$

ENGINEERING SPECIALTIES.

A Renewable Seat Valve.

The Lunkenheimer Company, Cincinnati, Ohio, have recently designed a renewable seat regrinding valve, which differs from the well-known Lunkenheimer regrinding valve, only in the construction of the disc and seat. The disc 12 is provided with a projecting ring, which enters the valve-seat ring 13. Its principal function is the preservation of the seat, and this is accomplished in a two-fold manner. First, as it enters the cylindrical part of the seat it deflects the current of steam from the seat-ring face, thus, it is claimed, preventing the wire drawing, which would otherwise occur. This feature is especially important should the valve be left partly open for any length of time. Secondly, it is claimed, the seating surface is kept free from scale and grit by the action of the thin current of steam discharged over it as the disc is brought home. Another function of this ring is the preven-

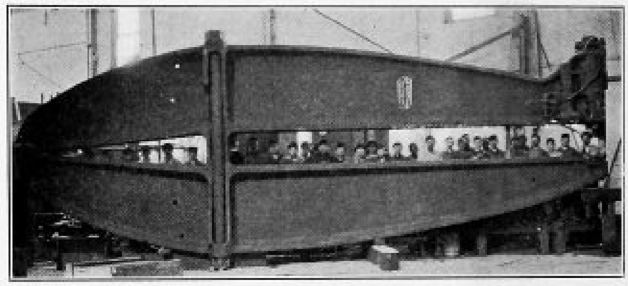


tion of waterhammer, which is caused by the sudden admission of steam, for it will readily be seen that no matter how quickly the hand wheel may be operated, the flange will only permit the steam to enter gradually. The seat 13 is renewable, and can be removed from the valve body by using a flat bar to engage the lugs on the inside of the ring. The Lunkenheimer Company call particular attention to the fact that the seat may be reground a number of times before it is necessary to renew it. Not only is the seat renewable, but all of the other wearing parts, including the disc, can be renewed if necessary. The hub is securely held to the body by means of a union ring, owing to which it is claimed that it is impossible for the hub and the body to become corroded together, as the thread which holds the union to the body is protected at all times from the action of the steam, the joint being made between the flange on the hub and the neck of the body. This connection also acts as a tie or binder in screwing over the body, and tends to strengthen the valve. The stuffing-box can be repacked under pressure when the valve is wide open, as a shoulder on the stem, directly above the threads, forms a seat beneath the stuffing-box. All valves above the ½ inch size have a gland follower in the stuffing-box.

The valve is designed for 200 pounds working pressure, and is made in both screw and flange ends, with either English or American standard pipe threads and flanges. With the exception of the seat rings, the valve is made entirely of a high grade of bronze, conforming to the United States navy specifications. The seat rings are made of hard, close-grained nickel, and will permit the regrinding many times over. To regrind unscrew the union ring 5, take the trimmings from the body and place a little powdered sand or glass and soap or oil on the disc, inserting a wire or pin through the slot in the disc lock-nut and hole in the stem. Then replace the trimmings in the valve body and regrind, leaving the ring unscrewed, so that the hub rotates in the body and acts as a guide for the stem while regrinding.

A Large Hydraulic Riveter.

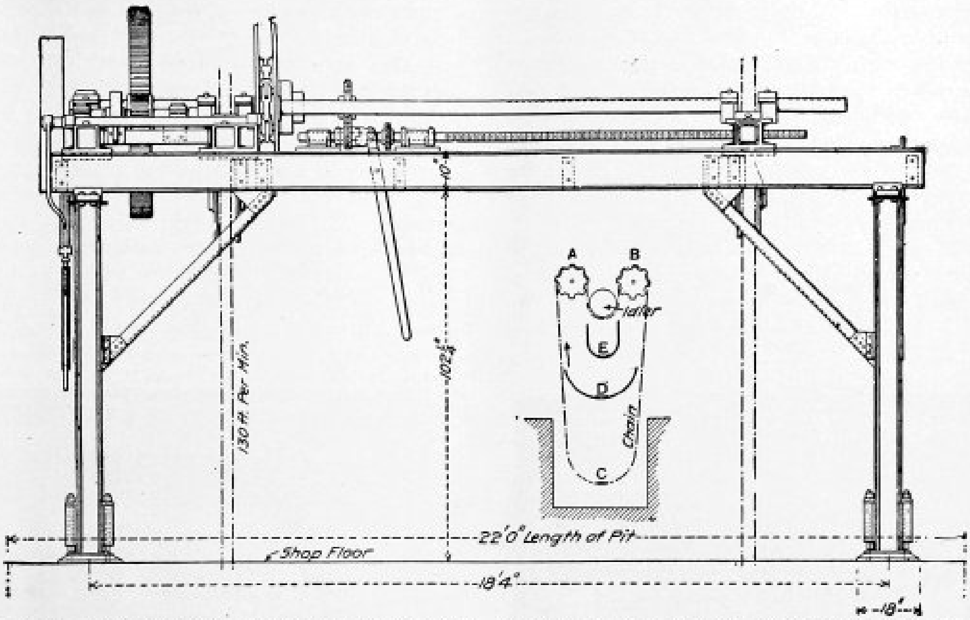
What is claimed to be the largest hydraulic riveter ever constructed is the 23-foot gap machine built by R. D. Wood & Company, Philadelphia, Pa., details of which are shown in the illustration. It is a six-power riveter with capacities



ranging up to 100 tons as a maximum. The riveter was made even heavier than usual for this class of machinery in order to keep the deflection as low as possible. It has been found that with the maximum pressure of 100 tons the deflection is less than ⅝ of an inch. The machine as completed stands 39 feet tall over all.

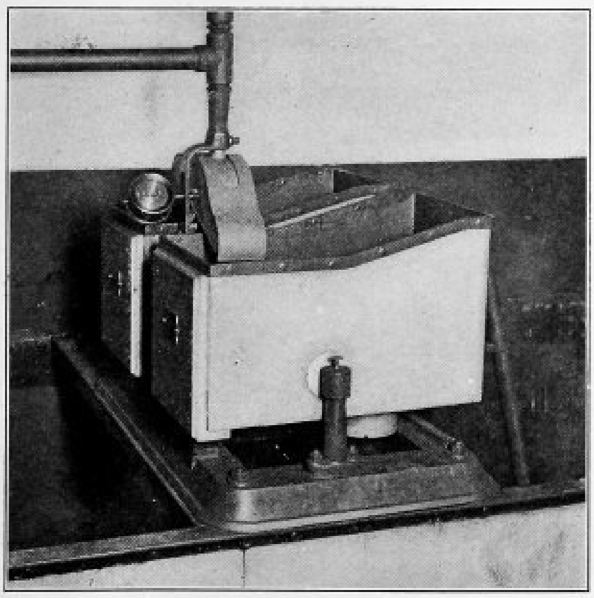
Leinert's Liquid Meter.

In any steam-generating plant it is an advantage to have some means of measuring the water fed to the boiler, since only by actually measuring the amount of water evaporated, and the amount of coal burned, can the actual efficiency of the plant be determined. A device for this purpose, which operates automatically and takes up comparatively small space, has recently been placed on the market by Holden & Brooke, Limited, Manchester, England. A distinguishing feature of this meter is, that the measuring is done by weight, and not by volume. The apparatus consists, as shown in the illustration, of two tanks of equal size, which are mounted on knife edges attached to axles, which divide the tanks into two unequal parts. Each tank is fitted at one end with a syphon pipe, and at the other with a number of weights. The liquid to be measured flows through a gutter or scoop, which is pivoted so as to direct the liquid first into one tank and then into the other. The weights are so adjusted that until the tanks are filled with the liquid up to a certain height, they remain in a horizontal position, but as the liquid rises above that point, the weight of the liquid overbalances the weights at the end of the tank, and the tank is tilted, causing the liquid to flow out through the syphon pipe. After the syphon has been started, and the level of the liquid in the tank has fallen sufficiently, the tank tilts back again to its original position, by the influence of the weights, while the syphon continues its action until the tank is emptied. As each tank is filled and tilted it suddenly strikes the gutter, through which the liquid is flowing, changing its position, so that the liquid is directed into the other tank, where the same operation is repeated. Both tanks are, therefore, automati-



cally filled with fresh liquid, while the measured liquid flows into a reservoir or other receptacle as desired. The number of times each tank is filled and emptied is registered by an indicator which is connected to both tanks.

The tilting of the tanks, and consequent record on the indicator, is entirely dependent upon the introduction into the



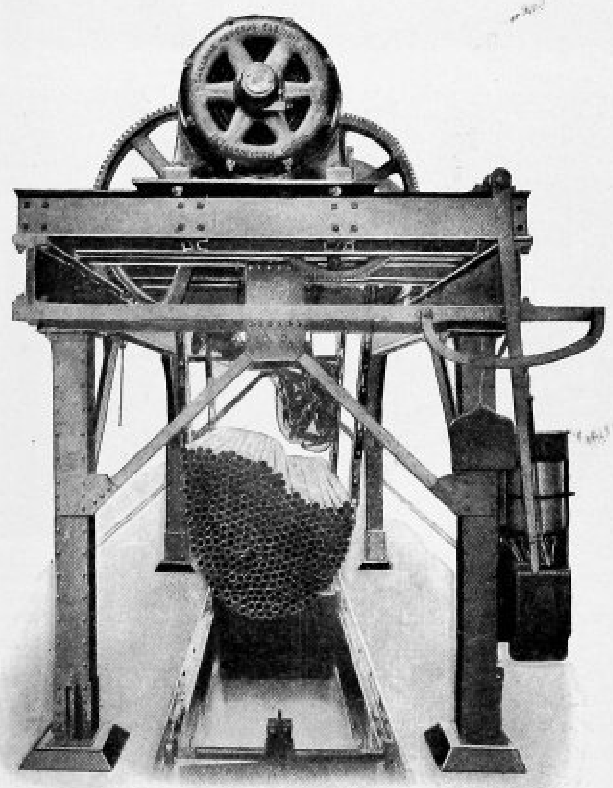
tanks of a definite weight of liquid, irrespective of variations in volume.

This specialty is handled in America by W. Leinert, 155 Maiden Lane, New York.

The Ryerson Flue Cleaning Machine.

Until recently there was possibly no department of railway repair work which had shown less improvement than that devoted to cleaning locomotive boiler tubes. Almost everyone is familiar with the old type of drum rattler, which at the most has a capacity to handle 100 tubes at a time, and which is noisy, dusty and consumes a large amount of power in operation. These objections, supplemented by the great handling expense attendant upon the operation of the drum rattler, prompted the effort and study which resulted in the design and development of a flue-cleaning machine by Jos. T. Ryerson & Son, Chicago, Ill.

It is claimed that the Ryerson flue-cleaning machine will handle 500 2-inch tubes of any length up to 24 feet at one time, or about five or six times as many flues as can be well handled at one time in a drum rattler. Furthermore, with

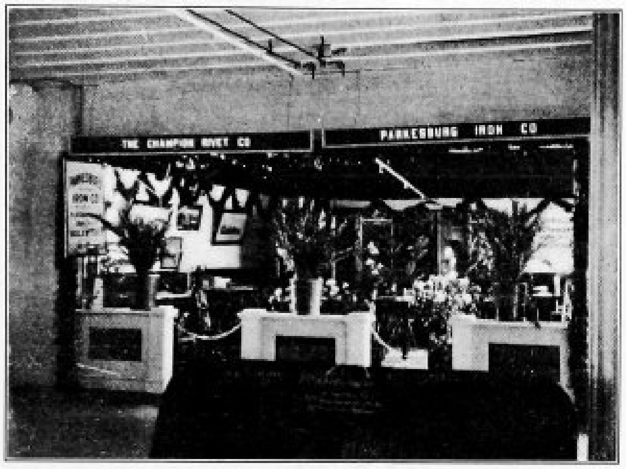


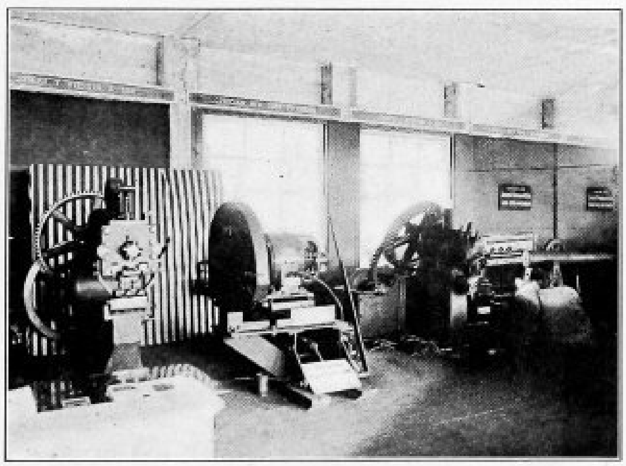
the Ryerson machine, there is no handling of the tubes necessary, the cradle chains of the machine being so arranged that the flues after being loaded on the truck and run under the machine, can be picked up by the power of the machine and lowered into the pit. The time claimed for this whole operation is but two or three minutes, and all labor is done away with except that required to push the flue car under the machine. To remove the clean tubes from the machine and reload on the car takes the same length of time.

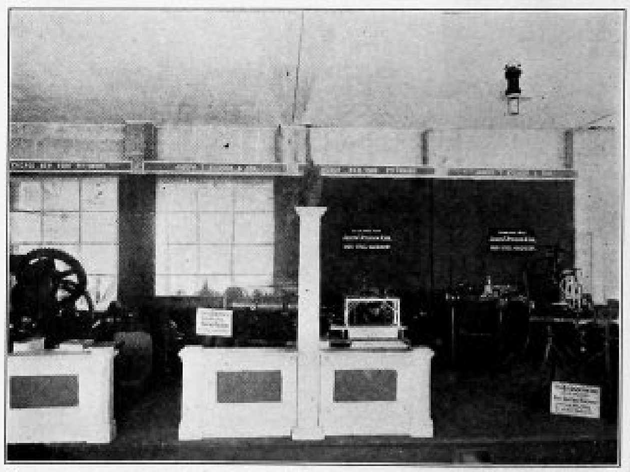
Another great advantage claimed for this machine is the lessening of the noise. The rattling takes place in the pit below the machine and under the water. This makes the machine much less noisy than the drum rattler, while the water assists in cleaning the tube on the outside, and at the same time that it removes the scale and other material the soot and dirt is washed out from the inside of the tube.

A good idea of the construction of the machine can be obtained from the illustrations. It will be seen that the flues while being cleaned are suspended in the water by two specially-made, wide-faced, case-hardened, wrought-iron chains, forming continuous loops, in which the flues roll over and over upon themselves as the chains are driven. All gearing is overhead, and driven by a direct-connected motor, or if desired, by belt. Fenders are provided to keep the flues in position in the pit, and these are adjustable to flues from 8 to 24 feet in length. The rear cradle chain is supported by a traverse carriage, which is moved toward or away from the front chain by screws driven by the main driving motor, thus adjusting the chains to the length of flues handled. The diagram clearly illustrates the method of raising and lowering the flues. The sprocket "*A*" is keyed to its shaft, and drives the chain when the motor is started. The sprocket "*B*" is keyed to its shaft, which is independent of the shaft "*A*," and receives its motion from the weight of the chain when it is in motion. If the chain moves in the direction of the arrow, and the shaft "*B*" is prevented from moving by means of the strap brake shown, the loop at "*C*" will be correspondingly shortened and the tubes will thus be raised out of the pit. They are then placed on a push car, which can be run under them. By this arrangement flues are lowered and raised by the machine itself, independent of the crane service of the shop. Vice versa, the flues to be cleaned are brought over the pit on a push car, lifted from the car by the chains, the car removed, the flues lowered into the pit and the machine started.

In addition to the type of machine illustrated the Ryerson Company also offer a machine which works on the same principle and has the same capacity, but which is designed to be used in such shops as have an air hoist or crane available over the machine. In such cases the overhead structural steel frame work is not used, and the supporting chains pass under the tank. A sling chain, which is left in the pit, is thrown over the tubes after the rattling, and by this means is raised with the crane or hoist.







SOME EXHIBITS OF INTEREST TO BOILER MAKERS AT THE MASTER MECHANICS' CONVENTION, ATLANTIC CITY, JUNE 22, 23 AND 24.

A 70-H. P. horizontal tubular boiler, weighing about 50 tons, exploded in the Kern River oil field, California, on Oct. 19, 1907. The explosion caused the boiler to make a remarkable flight of 1,220 feet, during which it cleared the top of a derrick 74 feet high. It has been impossible to fix the cause of the explosion, for, as usual, the fireman insists that the gage showed plently of water in the boiler just before the explosion occurred.

SELECTED BOILER PATENTS.

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

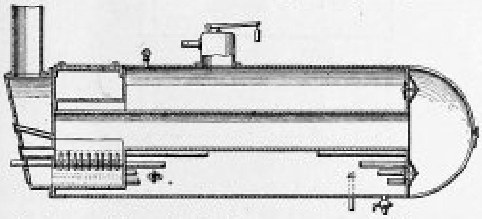
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

879,806. BOILER FURNACE. William N. Best, New York, N. Y., assignor to the International Calorific Company, Los Angeles, Cal., a corporation of California.

Claim.—A furnace having a combustion chamber, a burner communicating therewith, a bridge wall, a cross-wall spaced therefrom to form an air passage, a conduit for delivering air from the outside atmosphere to said passage, and an arch at the upper portion of the bridge wall closing the passage between the cross-wall and the bridge wall and extending into the combustion chamber, said cross-wall being provided with perforations adjacent the lower side of the arch, whereby air may flow from the air passage between the walls into said combustion chamber and beneath said arch. Two claims.

882,456. COMBINED BOILER AND FURNACE. William Jefferson Ellis, Andrews, N. C.

Claim.—A combined boiler and furnace, comprising a boiler having an open-top fire-box at one end and a smoke-box arranged at each end, a combustion chamber extending centrally through said boiler and communicating at its opposite ends with said smoke boxes, and having an opening in its bottom



communicating with said fire-box, a water jacket surrounding the upper portion of said chamber within the fire-box, said boiler having a fuel supply opening arranged above the jacket portion of said combustion chamber, tubes extending through said boiler and connecting said smoke-boxes, and a plurality of air supply passages through the front smoke box into the fire-box. One claim.

882,420. SHEET FOR BOILER FURNACES. Thomas C. Rogerson and Philip Rentchler, Jacksonville, Ill.

Claim.—A sheet forming a wall between the fire-box and water space of a steam boiler, said sheet having concaved dents projecting from its plane into the area of the water space and convexed dents projecting from its plane into the area of the fire-box, said dents being alternately arranged in

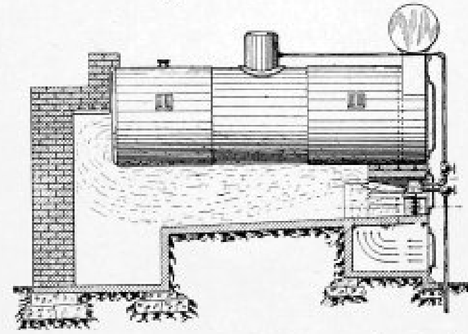
rows and stay-bolts connected at their outer ends with the outer wall of the water space and at their inner ends with said sheet at points lying in the plane of the body portion of the sheet so that the ends of the said stay-bolts lie at points between the planes occupied by the middle portions of the oppositely disposed dents. One claim.

878,261. STEAM BOILER. Israel Williams, of Lima, Ohio.

Claim. In an apparatus, the combination with a boiler, of a feed-water heating and purifying chamber above the same means dividing said chamber into a series of communicating compartments, and gravity and automatic feed pipes connecting said boiler with the chamber. Ten claims.

882,205. MEANS FOR BURNING OIL. Thomas C. Mason, Los Angeles, Cal., assignor, by mesne assignments, to Mason Smokeless Combustion Company, Carson City, Nev., a corporation of Nevada.

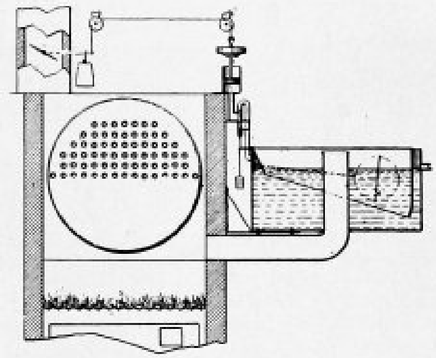
Claim.—The apparatus for effecting the complete combustion of oil, consisting of a bottom chamber, doors at the front of said chamber, openings one at each side and at the inner end of the bottom chamber leading into lateral flues, one such flue on each side of the apparatus, a transverse flue uniting the



lateral flues, the single central discharge flue having curved walls projecting inwardly to the lower part of the combustion chamber, the flue having curved walls being of gradually decreasing cross sectional area, a burner in the combustion chamber, pipes connecting the burner within the combustion chamber with sources of steam and oil, all operating to cause the air flowing through the flues to become highly heated and to be discharged at a high velocity beneath the oil burner in the combustion chamber in the manner and for the purposes. One claim.

883,283. COMBUSTION AND DAMPER REGULATOR FOR FURNACES. Francis H. Brown, of Philadelphia, Pa., assignor to Combustion Engineering Company, a corporation of Delaware.

Claim.—In a device, the combination with a furnace, of a damper controlling the discharge of gases therefrom, a pivoted member operatively connected with said damper, and



an adjustable counterbalance for said member, said member being normally maintained in a substantially horizontal position, and being actuated in one direction by a constant pressure and in the other direction by the pressure of the furnace gases. Nine claims.

880,385. SPARK ARRESTER. Wallace F. MacGregor, Racine, Wis., assignor to J. I. Case Threshing Machine Company, of Racine, a corporation.

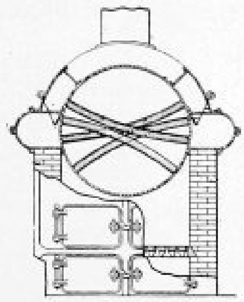
Claim.—In spark arresters, the combination with the stack and with the screen adjustable therein, of a ring frame secured to said screen, a shifter rod secured at its upper end to one side of said ring frame, fixed guides at the side of the stack for said shifter rod, said guides being spaced apart to compel the movement of said rod in straight line direction, a handle at the lower end of said rod and means for holding said rod and screen in a plurality of adjusted positions. Six claims.

881,353. BOILER-TUBE CLEANER. Andrew Thompson Stewart, Washington, District of Columbia.

Claim.—A tube cleaner comprising a rod, a head arranged on the rod and having a circumferential, rearwardly and outwardly disposed groove, a tubular end part mounted on the rod and having circumferential forwardly and outwardly disposed grooves, bow springs extending between the head and tubular part and having their forward ends disposed in the groove of the head and their rear ends disposed in the rear groove of the tubular end part, stiffening strips connected at their forward ends to the bow springs and having their rear ends disposed in the forward groove of the tubular end part, blades arranged diagonally and each connected at its rear end to one bow spring and at its forward end to an adjoining bow spring, and means for adjusting the rod through the tubular end part. Two claims.

883,095. STEAM GENERATOR. Harry Del Mar, of New York, N. Y., assignor to Boilers & Engineering Company, of Jersey City, N. J., a corporation of New Jersey.

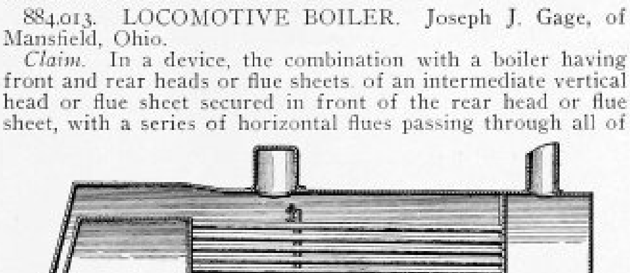
Claim.—A steam generator comprising a water-holding shell, combustion chambers at the sides of the shell, said combustion chambers being closed at the ends, outlet flues parallel with the combustion chambers, cross tubes leading through the



shell from the under side and discharging into the combustion chambers, cross tubes leading through the shell from the combustion chambers into the outlet flues, longitudinally arranged fire tubes leading through the shell and means for directing the products of combustion from the outlet flues to the longitudinal fire tubes. Two claims.

884,013. LOCOMOTIVE BOILER. Joseph J. Gage, of Mansfield, Ohio.

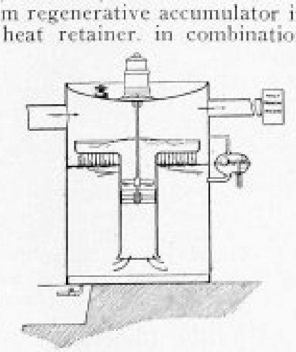
Claim. In a device, the combination with a boiler having front and rear heads or flue sheets, of an intermediate vertical head or flue sheet secured in front of the rear head or flue sheet, with a series of horizontal flues passing through all of



said heads or flue sheets, the intermediate head or flue sheet supporting the weight of the flues between the front and rear heads or flue sheets, and the said intermediate head or flue sheet being a double plate which allows one of the plates to be drawn up or down and which securely fastens the flues in said intermediate head or flue sheet. Four claims.

884,610. STEAM REGENERATOR. Auguste Camille Edmond Rateau, of Paris, France.

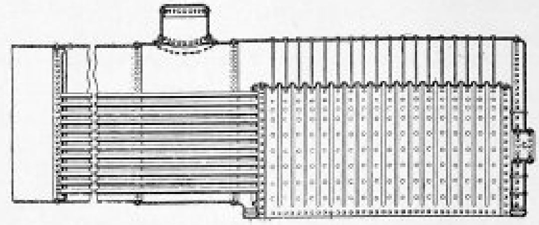
Claim. A steam regenerative accumulator in which liquid is employed as a heat retainer, in combination with pumping



mechanism for effecting circulation of the liquid, and a motor for operating said mechanism and itself operated from a source of power other than the steam to be regenerated. Six claims.

885,123. STEAM BOILER. William H. Wood, of Media, Pa.

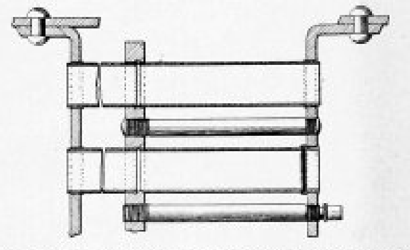
Claim. In a steam boiler, the fire-box made with a flue sheet having its top and side edges provided with a flange riveted to the sides and crown of the fire-box and having the metal between the tubes and flange pressed into grooved



form in which the direction of the depth of the groove is substantially at right angles to the general surface of the tube sheet, whereby the tube area of the sheet may yield under the expansive influence of the tubes relatively to the flange. Eight claims.

885,229. STEAM BOILER. John A. Doarnberger, of Roanoke, Va.

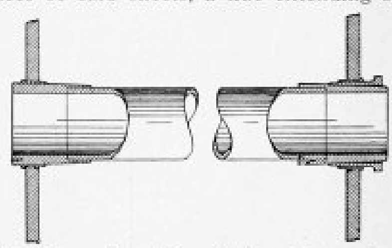
Claim. In a steam boiler provided with a reinforcing auxiliary flue sheet located intermediate the front and back



main sheets and secured in fixed relation therewith; two-part tubes each having one end fixed in a main flue sheet and the opposite ends fixed in the reinforcing auxiliary sheet. Three claims.

885,662. DETACHABLE BOILER FLUE. Alexander J. Bowden, of Minneapolis, Minn., assignor of one-half to Amos B. Robbins, of Elroy, Wis.

Claim. In a boiler, the combination, with the flue sheets spaced apart and in parallel relation with one another and having flue seats extending therethrough from one side to the other, said seats being tapered from the outer toward the inner surfaces of said sheets, a flue extending between said



sheets and having end sections fitting within the openings in said sheets, the section at the fire-box end of said flue being tapered from its outer end toward its inner end to fit the flue seat at that end, and having a suitable packing ring, and the section at the oposite end of said flue beinг tapered from its inner end toward its outer end, whereby both sleeves and the flue may be driven in the same direction out of the flue sheets, and an oppositely-tapered sleeve inclosing said last-named section and fitting between it and its flue seat and having a suitable packing ring. Three claims.

882,959. MARINE BOILER. Herbert E. Penney, of Minneapolis, Minn., assignor to Nott Fire Engine Company, of Minneapolis.

Claim.—In a marine boiler, the combination with a water-ring and a steam-ring and a series of closely arranged return pipes connecting them and inclosing the combustion chamber, of a steam-dome in communication with the steam-ring, a cylindrical drum in communication with the base of the steam-dome and with the water-ring, and tube sections comprising upper and lower radial headers connected to said drum, and series of coils extending spirally around the drum and connecting the lower with the upper headers. Three claims.

THE BOILER MAKER

VOL. VIII AUGUST, 1908 No. 8

LOCOMOTIVE BOILERS FOR THE PARIS-ORLEANS RAILWAY.

The Schenectady works of the American Locomotive Company has recently completed an order of thirty De Glehn four-cylinder balanced Pacific-type locomotives for the Paris-Orleans Railway of France. These locomotives were constructed to specifications and drawings furnished by the railway company, and as all the dimensions on the drawings were given in the metric system, the work in the shops was carried out to these dimensions. It is seldom that work is carried out in the United States according to the metric system of measurement, and it is interesting to see how easily American workmen can adapt themselves to this change. The use of this system of measurement of course necessitated the introduction of many new standards and gages, and the training of the men in the use of the metric units. In spite of the fact, however, that this is the first large order which has been undertaken by this company with this system of measurement, no difficulty was experienced in its use.

The boilers for these locomotives, as shown by the illustrations, are slightly different from the ordinary boiler which is used in American practice for the Pacific type of locomotive. The boiler is of the straight-top type with a Belpaire fire-box, and the main features which differ from American practice are the shape of the fire-box, the manner of bracing and the material used for the fire-box and staybolts.

The boiler is 10.937 meters (35 feet 10⅝ inches) long over all; the length of the fire-box is 3.150 meters (10 feet 4 inches); and of the barrel, or cylindrical part of the boiler, 7.787 meters (25 feet 6 9/16 inches), the mean diameter being 1.68 meters (5 feet 6 9/64 inches). The shell is built of three courses of steel plate, 20 millimeters (25/32 inch) thick; the first and second courses are each 2.49 meters (8 feet 2 1/32 inches) long and the third course 1.135 meters (3 feet 8 11/16 inches) long; riveted to this is the smoke-box shell, which is 1.91 meters (6 feet 3 3/16 inches) long. The longitudinal seams are triple riveted double-butt strap joints, fastened with rivets 24 millimeters (61/64 inch) diameter. The inside straps are 355 millimeters (14 inches) wide by 20 millimeters (25/32 inch) thick and the outer straps 222 millimeters (8¾ inches) wide by 16 millimeters (⅝ inch) thick. The steam dome, 650 millimeters (2 feet 1 19/32 inches) high and 640 millimeters (2 feet 1 13/64 inches) inside diameter, is located on the second course of the shell.

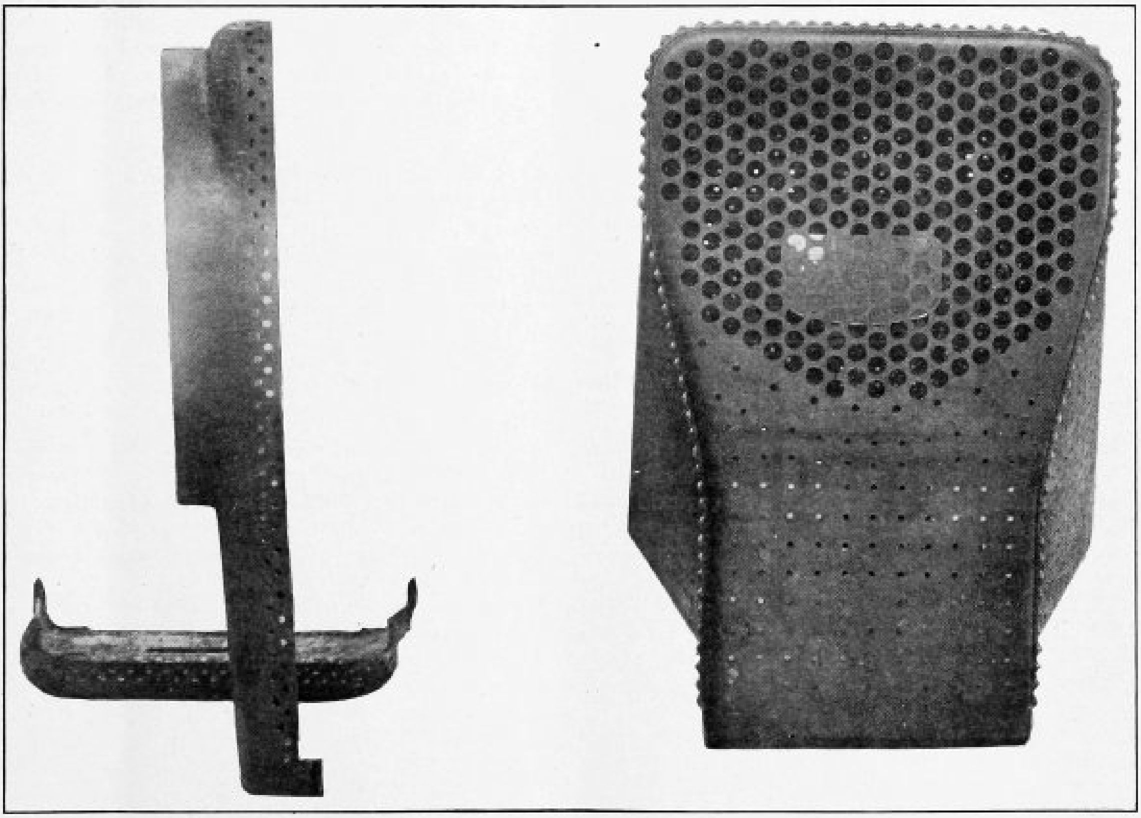


FIG. 1.—THROAT SHEET AND FIRE-BOX.

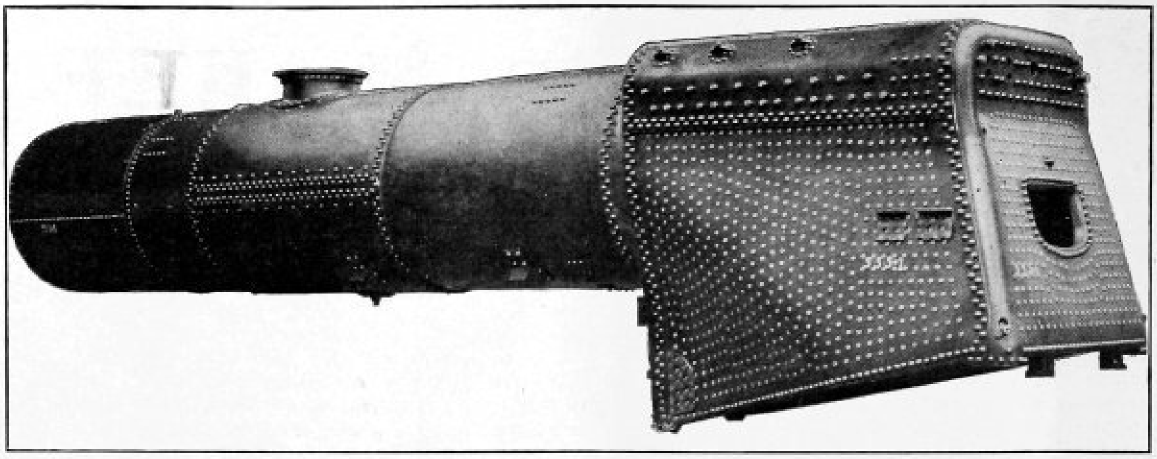


FIG. 2.—COMPLETED BOILER SHOWING PECULIAR SHAPE OF FIRE-BOX.

The girth seams are double riveted lap joints fastened with the same size rivets as the longitudinal seams.

The most interesting feature of the design of the boiler is the peculiar shape of the fire-box, which is clearly shown in the illustrations. The fire-box extends out over the frames at the back end, and is narrowed down at the front end to come between the frames. This peculiar shape is made necessary because of the fact that the rear driving wheels are so located that they extend back of the front end of the fire-box instead of being ahead of the fire-box, as is the usual practice in the American design of a Pacific-type engine. Thus the width of the fire-box at the back end is 1.912 meters (6 feet 3¼ inches), while at the front end it is only 1.017 meters (3 feet 4 1/32 inches). The upper part of the fire-box is 1.375 meters (4 feet 6⅛ inches) wide throughout the entire length.

This narrowing of the fire-box at the front end results in peculiar-shaped inside and outside side sheets. These sheets were flanged to the required shape in a hydraulic press. It will be noticed that the sides and crown of the fire-box are in one sheet, which, since it was made of copper, was flanged cold. The sides are formed from the flat sheet in one operation each, after which the bends at either side of the crown were made in bending rolls. The outside fire-box sheets were of steel, and were, therefore, heated and flanged in the ordinary way, as was also the top sheet. As the fire-box has the same width of crown throughout the entire length it would apparently seem impossible, because of the mud ring being contracted at the front end, to insert the fire-box after the back head had been riveted in place. However, by starting it in toward the back end of the mud ring and swinging it around with a partly circular motion this was accomplished without any difficulty.

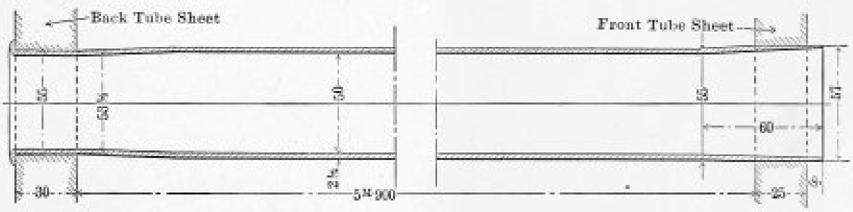


FIG. 3.—DETAILS OF TUBE.

The throat sheet, which is clearly shown in Fig. 1, entirely encircles the shell of the boiler. This sheet was flanged in two operations, the circular flange over the shell of the boiler being first formed in a hydraulic press. Afterwards

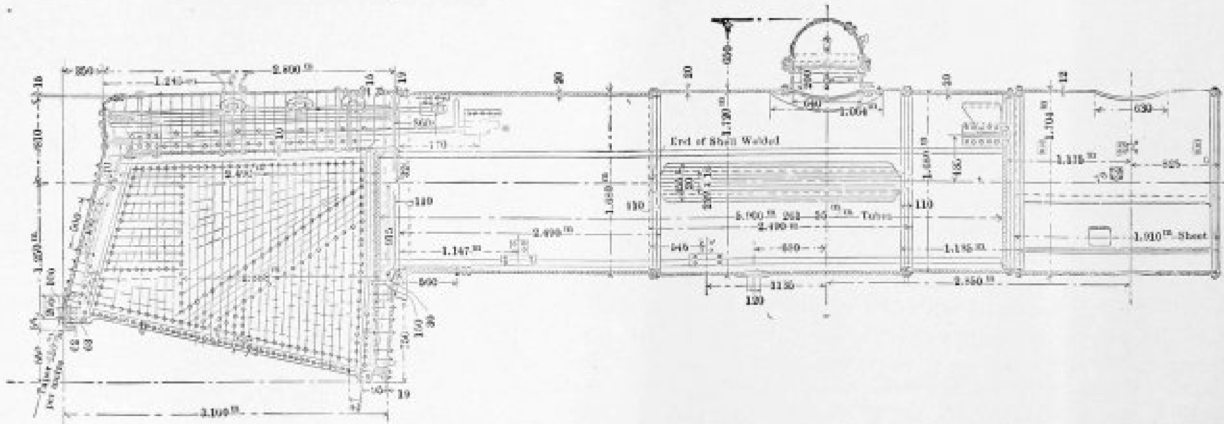


FIG. 4.—SECTIONAL VIEW OF BOILER SHOWING DETAILS OF BRACING.

the piece was clamped on to a former and the sides flanged over by hand with wooden mauls.

Since the fire-box is of copper all the staybolts in the water legs are of manganese bronze. These staybolts are provided with telltale holes about ¼ inch in diameter, but these holes,

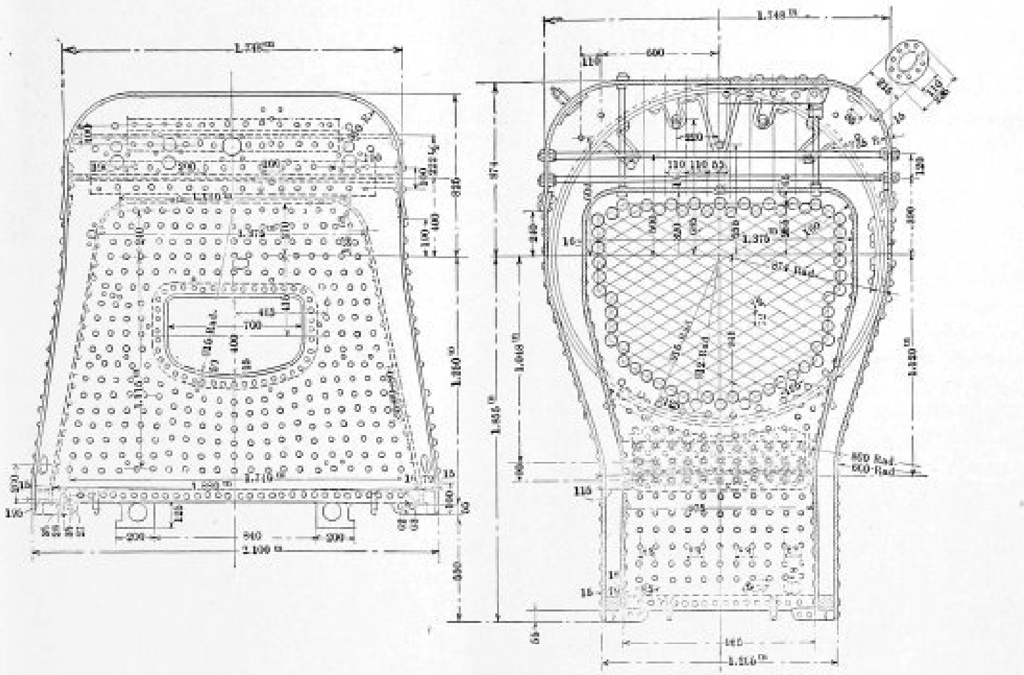


FIG. 5.—SECTIONS THROUGH THE FIRE-BOX.

instead of being drilled only about one-half the length of the bolt, which is customary in American practice, were drilled straight through the bolt, the hole on the inside being plugged up by riveting over the staybolt head.

The crown and other boiler stays are of Falls hollow staybolt iron and it will be noticed that the design of the crown stays also differs from the practice in this country. All the

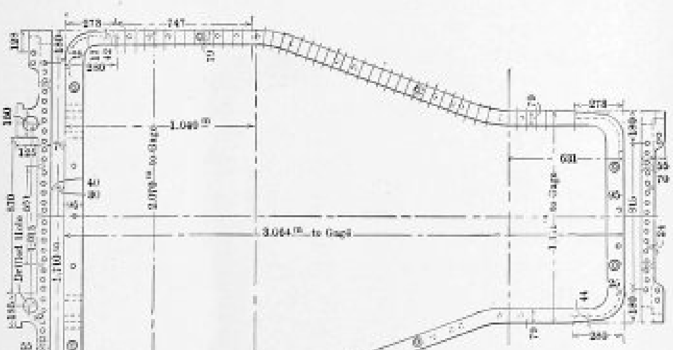


FIG. 6.—MUD RING OF HAMMERED IRON, 3 7/64 INCHES THICK.

crown stays are provided with bolt heads at the bottom end and with nuts and washers at the upper end, instead of being riveted over, as is the usual practice here. The first two rows of crown stays are expansion stays, being fastened to the outside sheet by means of double-angle bars. Details of these stays are clearly shown in the sectional view of the boiler, Fig. 4. One advantage of this design of expansion stays is that the pin connecting the crowfeet to the angle bars is above the water line, so that it will not be as quickly rusted in place as when it is below the water line, as is usual in American locomotive boiler design. The design of the longitudinal boiler braces is also of interest. As will be seen, they are shaped in the form of a jaw at the back end and connected by means of pins with crowfeet on the back head, while at the other end they are threaded and passed through U-shaped brackets riveted to the shell of the boiler. They are held in position by nuts and washers which screw up against these brackets. This is a construction which permits of putting the proper tension on each brace separately.

There are 261 tubes 55 millimeters (2 11/64 inches) outside diameter, and 2½ millimeters (3/32 inch) thick; the front tube sheet is 25 millimeters (63/64 inch) thick, and the back tube sheet 30 millimeters (1 3/16 inches) thick; while the distance between tube sheets is 5.9 meters (19 feet 4 9/32 inches). The tubes are swedged down to 53½ millimeters (2 7/64 inches) outside diameter at the back tube sheet, while at the front tube sheet they are expanded to 57 millimeters (2¼ inches) outside diameter. The tube holes in the back tube sheet are slightly tapered and the tubes are beaded over at the fire-box end. At the front end, the tubes are simply expanded without being beaded.

Cause of Leaky Flues.

At the last convention of Master Boiler Makers, Mr. F. P. Roesch, master mechanic of the Southern Railway at Spencer, N. C., outlined briefly some experiments which he had made to determine the relative contraction and expansion of the flues and shell of a locomotive boiler immediately after the fire was knocked and the boiler was cooling off. Writing further on this topic in a recent issue of *Railway and Locomotive Engineering*, Mr. Roesch states that having had considerable experience with locomotive boilers in various sections of the country, and feeling experienced in the handling of all kinds of water, good, bad and indifferent, the question of the cause of flue leakage has always been an interesting one to the writer, and for this reason different experiments were undertaken in order to determine, if possible, what was the most prolific cause of leakage. At the last Master Steam Boiler Makers' convention, the question of flue leakage was discussed, and it was there decided that more flue troubles were due to poor handling of the engine on the road by the engineer and fireman than were caused by poor work in the first place. In fact, the sense of the convention appeared to be that neglect on the part of the engineer and fireman was the principal cause.

We regret that we cannot agree with the majority of the Master Steam Boiler Makers, as the result of quite a number of experiments made by the writer proved conclusively that flue leakage was not due so much to the abuse on the line or road by the engineer and fireman as by the abuse at terminals, this abuse being the admission of cold air and the too frequent washing of boilers. In a series of experiments it was found that by knocking the fire out and leaving the water in the boiler, allowing it to cool off gradually through the natural circulation of air through the tubes, that the flues contract considerably more than the boiler in their initial contraction. This was found to be due to the flues being exposed directly to the cold air currents passing through them, while the boiler was protected by the lagging on the outside and water on the inside. At first glance it may be thought that the heat contained in the water would naturally be imparted to the flues so that they would retain the same temperature as the water, regardless of the amount of air circulated through them. It has been found, however, that scale on a boiler tube offers considerable resistance to the passage of heat from the flue to the water, and consequently it must offer the same resistance from the water to the flue. In other words, the scale is simply an insulating medium. After the boiler undergoing the test had been allowed to stand six hours and steam had been reduced from 135 pounds to 6 pounds, with a reduction in the temperature of the water from 358 to 233 degrees, it was found that the flues had contracted 9/64 inch, while the boiler had contracted 11/64 inch. Thus it will be seen that when the boiler first began to cool, the flues contracted 1/32 inch more than the boiler, but that in the final contraction the boiler contracted 5/64 inch more than the flues.

These experiments were continued with different engines and under different conditions, and in all cases the results were found to be practically the same—that is, that the flue leakage was caused almost entirely by the admission or circulation of cold air through the flues after the fire had been knocked. The variations in contraction between the flues and the boiler obtained just the same, regardless of whether the water was allowed to remain in the boiler or was entirely drawn off. In one test made after knocking the fire, we let the water out of the boiler and found the temperature of the boiler at that time to be 172 degrees. Prior to letting out the water, measurements of the flues and boiler were taken. After the water was all out, measurements were again taken, and we found that the boiler had contracted 10/64 inch, the top flues 9/64, the middle flues 11/64, and the bottom flues 11/64. After standing three hours, the boiler was filled with water at 98 degrees and measurements again taken. It was now found that the total contraction of the boiler was 20/64 inch, top flues 18/64, and bottom flues 19/64. This proves conclusively that knocking the fire produces a pushing and pulling action of the flues in the flue sheet, and as the flues are exposed to the greatest amount of heat at the firebox flue sheet, the loosening of the flues will naturally take place at this point. Cases have been noticed, however, where flues were not firmly set in the front flue sheet that they were pulled forward and back in this sheet.

From the above experiments and results obtained, the theory was formed that the principal cause of flue leakage was due to the circulation of cold air through the flues. This theory is borne out by the fact that many cases have been noticed where engines that were giving trouble on account of leakage while in through freight service were afterwards placed in work train service and held out on the road, gave comparatively little trouble afterwards, as, while held out on the road, the fire was not knocked, but simply banked when the engine was laid up at night, whereas, while the engine was in through freight service, the fire was usually knocked at terminals. The theory is further supported by the fact that where bad water obtains, making it necessary to wash engines at the end of each trip, if the water is treated chemically so as to precipitate the incrusting matter in the form of sludge, and this sludge is blown out by means of blow-off cocks, and the boiler, instead of being washed at the end of each trip or at the end of every three to six hundred miles' run, is now allowed to run between fifteen to even thirty days between washings, the flue trouble decreases in a corresponding ratio as the decrease in boiler washings. Remarkable decreases in flue leakage have been noted where bad water has been treated chemically either before or after the water was put into the boiler. The decrease in leakage, however, was not due to the chemicals put in the water, but to the fact that owing to the chemical treatment, it was possible to run engines longer between washings, thereby decreasing the number of times necessary to knock the fires.

If the above theories are accepted as correct, the natural conclusion will be that the proper care of boilers resolves itself into knocking the fires as few times as possible. In other words, when engines arrive at terminals, instead of knocking the fires, simply clean and bank same, leaving the fire door shut as much as possible. After the fire has been cleaned and banked, the ashpan dampers should be closed except when necessary to replenish the fire with fresh fuel. In this case the dampers should be open before the firebox door is open. In order to accomplish this the chemical treatment of water is strongly advocated, as, by this treatment, it is possible to run engines longer between washouts. When necessary to knock a fire, however, in order to wash the boiler, or to make repairs to the interior of the firebox, grates, etc., the stack should be covered with a metal plate immediately after the fire has been knocked and the engine housed. In order to prevent sweating and clogging of the netting in the front end, this stack covering should have an opening, or hole, in it about one inch in diameter, so as to permit the slow escape of the moisture-laden gases which would naturally form.

In the course of time flues on account of continuous service and the pushing and pulling action above referred to, owing to repeated coolings, will naturally become somewhat loosened in the sheet, and consequently begin to leak. When this leakage begins to take place, we do not advocate the rolling of flues, but prefer a light "prosser," after which the flues should again be beaded down.

There is another very strong argument to be advanced in favor of chemical treatment of boiler feed water, and that is that when water is treated, either before or after it is put into the boiler, and the solid matter precipitated in the form of a sludge that can readily be blown out or removed by washing, there is not that tendency for solid or incrusting matter to work itself between the various joints of the boiler, such as the joints made between the flue and flue sheet, or by the firebox seams, etc., which, owing to the expansion and contraction of the boiler, will gradually have a tendency to force the sheets apart wherever this incrusting matter enters, and so with every change of water have a tendency to cause excessive leakage as in changing water, the incrusting matter will tend to dissolve, and leakage is bound to occur.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION.

Proceedings of the Twentieth Annual Convention.

The twentieth annual convention of the American Boiler Manufacturers' Association was held at the Marlborough-Blenheim Hotel, Atlantic City, on July 14, 15 and 16. In the absence of President M. F. Cole, of Newnan, Ga., First Vice-President T. M. Rees, of Pittsburg, called the convention to order and presided over its deliberations. He referred in his opening remarks to the past history of the association and its continued efforts in bringing to the attention of both the State and National authorities the needs of the trade with regard to improvements in inspection of boilers, land and marine, and the necessary revision of the regulations where by lapse of time and the natural progress of events they had grown obsolete and out of harmony with existing conditions and necessities. He congratulated the association upon the action of President Roosevelt in appointing a commission to work along these lines, and reminded his hearers that it was now the duty of the association members and the trade generally to bring to the attention of this commission all facts and information that would tend to facilitate their work and keep them advised as to modern requirements. This is all the more important, since federal laws and department regulations have an indirect and far-reaching effect on State and municipal legislation on these subjects, and all tend to greater uniformity of practice, better enforcement of reasonable and proper regulations and the ultimate protection of life and property.

Mr. Rees introduced Mayor Franklin P. Stoy, of Atlantic City, who gave the convention a cordial welcome to the city by the sea. Mr. W. H. S. Bateman, secretary of the associate members and supply men, responded briefly to the Mayor's address, after which he announced the entertainment features which were to be carried out during the convention.

Only a short session was held on Tuesday morning, and an adjournment was taken after the opening formalities had been concluded.

TUESDAY AFTERNOON SESSION.

At the afternoon session committees were named as follows:

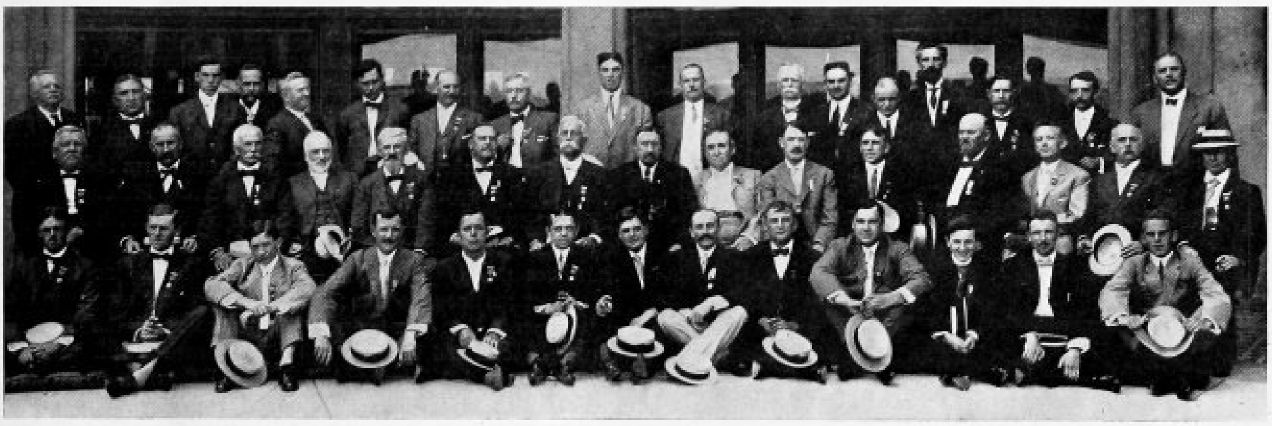
Time and Place of Next Meeting—H. J. Hartley, Philadelphia, Pa.; H. D. MacKinnon, Bay City, Mich.; Clifford Tudor, Cincinnati, Ohio.

Nominations—J. J. Finnigan, Atlanta, Ga.; Geo. N. Riley, Pittsburg, Pa.; John Rourke, Savannah, Ga.

Auditing—George N. Riley, Pittsburg, Pa.; J. Don Smith, Charleston, S. C.; D. Connelly, Cleveland, Ohio.

Arrangements—H. J. Hartley, Geo. N. Riley, J. D. Farasey.

Preliminary to the presentation of reports of committees and presentation of papers, which it was decided to take up on Wednesday, an informal discussion was held upon matters of general interest. This was opened by Col. E. D. Meier, president of the Heine Safety Boiler Company, who gave a review of the work of the association in its endeavor to obtain a higher grade of boiler plate and to reduce the sulphur content, etc. He also gave the history of the movement for uniform inspection laws, mentioning especially Mr. C. M. Schwab, of the Bethlehem Steel Corporation, the especial guest of honor of the convention, as being one who had at an early date exhibited a willingness to meet the boiler manufacturers half way in their efforts to obtain a better quality of steel for boiler plate, and who had given them valuable aid in this direction. For the benefit of those new members who were not conversant with the matter, Col. Meier gave a brief review of the work done in influencing a revision of the marine inspection laws by the government, a matter that is now well under preparation and from which the best results are to be expected.



MEMBERS AND GUESTS OF THE BOILER MANUFACTURERS' ASSOCIATION AT ATLANTIC CITY.

Mr. Hirsch, representing the Carnegie Steel Company, took an active part in the discussion from the standpoint of the steel manufacturers. He said that he had been greatly interested in Col. Meier's remarks, because he knew that he had been very active in the entire movement and knew whereof he spoke. He complimented the Colonel on having borne, along with other manufacturers, very patiently with the steel manufacturers, who on their part had been constantly endeavoring to improve the quality of their product. In the early days of the acid process it was found difficult to eradicate the impurities, but by the aid of chemistry and the study of experts great improvement has been accomplished, and manufacturers are ready to take forward steps constantly as fast as new developments come along that will make it possible to do so practically. This is not only desired by manufacturers to meet the demands of domestic trade but to enter fully and effectively into foreign markets. Steel manufacturers, however, are not infallible, and there yet remains a large field for further inquiry and investigation which they are carrying on all the time at great expense in the hope of securing ultimately all that can be wished for. Every year advances are being made in this direction. As an illustration of the effect of heat and an understanding of its laws as applied to the manufacture of steel, the speaker said that he had seen a steel plate bent cold flat on itself without injury, and then the opposite end of the same piece heated to a cherry red and turned over flat without fracture; but the same piece of plate when subjected to about 500 degrees F., and then bent flat, cracked like glass. In reply to the question as to why it was more difficult to reduce to a minimum the phosphorus and sulphur in acid steel rather than in basic steel, the speaker said that in the methods employed to-day in

COL. E. D. MEIER, PRESIDENT.
(Portrait from Steam.)

the basic process the phosphorus goes out with the slag, and the manufacturer is able to give the consumer basic steel with phosphorus almost nil. The sulphur is, however, still there to some extent, and will in the best practice range from .025 to .04 percent; and at present there seems to be no way of overcoming this ratio.

An interesting discussion followed, participated in by Messrs. Scannel, Stewart, Rees, Meier, Wilkinson, Mitchell, Bentley, Hartley, Smith, Schaaf, Connelly, Bateman, Thomas and MacKinnon, during the course of which possible explanations were offered for some of the flaws and imperfections found in boiler plate, such as those due to variation in roll, percentage of sulphur, segregation in the ingot, flaws from sand, runner brick, etc.

WEDNESDAY MORNING SESSION.

Report of Committee on Uniform Specifications.

Atlantic City, N. J., July 14, 1908.

Mr. President and Members of the A. B. M. A.:

Your committee begs to report as follows:

There have been two important developments growing out of the activities of this committee and the sanction of their work by previous conventions. They bear out the statement made, in former reports, that the educational effect of the work of this society will ultimately bring us nearer the desired end of uniformity in rules for construction and operation of steam boilers than any legislation which might be attempted.

The first of these events was the passage in 1907 of "An act relative to the operation and inspection of steam boilers" by the Legislature of the State of Massachusetts.

The second was the appointment by President Theodore Roosevelt of a commission on revision of laws relating to safety of life at sea. The necessity of such a commission was first pointed out by our association in our convention at Buffalo in 1901, and your present committee was instructed to propose legislation on the subject to the Treasury Department. Our repeated efforts to have such a commission created by law, and their failure, are matters of history. But the appointment by President Roosevelt of a commission of five experts to revise these laws may justly be claimed by us as the culmination of our labors. One of our members has received the letter from the acting recorder of this commission, which is herewith submitted as Exhibit "A."

As to the former important event we submit as Exhibit "B" the act passed by the Legislature of Massachusets, May 29, 1907; and as Exhibit "C," the rules formulated by the board of boiler rules under this act.

While the commission as appointed by the President does not, in its composition, represent the interests which we enumerated in our bills before Congress, the letter submitted shows that the commission desires to avail itself of the suggestions and comment of men experienced in the various branches covered by the steamboat inspection law, thus working towards the very end which was the object of our bill.

The chairman and one of the members of this committee being also members of the committee on uniform boiler specifications of the American Society for Testing Materials, made a report to that society on June 25, 1908, of which a copy is herewith submitted as Exhibit "D." In this report we confine ourselves mainly to the question of materials as the subject most pertinent to the work of the society mentioned.

It appears that the board of boiler rules of the State of Massachusetts had before them our uniform specifications of 1898, as amended in 1905, and followed them in most particulars. But in the classification of boiler plate they vary slightly from us. They adopt our terminology of flange and boiler steel, firebox and extra soft steel; they take our physical specifications verbatim, adding only certain modifications regarding the percentage of elongation for various thicknesses, and distinctly stating that steel shall be made by the open hearth process and will be considered as manufactured by the basic method, unless otherwise stated.

They also have a very carefully prepared homogeneity test, see page 19, par. 8, and page 20, par. 13.

In the chemical properties they have adopted the specification of the American Society of Testing Materials. These are decidedly too easy, as pointed out by your chairman in a report to that society. They permit slightly higher phosphorus than the A. B. M. A. specifications. We claimed further, that there was at present no sound reason for permitting a higher percentage of phosphorus in acid than in basic steel, and that the sulphur for all three classes of plate is too high. This report has been submitted to the committee on boiler steel of the American Society for Testing Materials, and we hope to induce them to adopt our specifications. This would give uniformity, because the A. B. M. A. specifications have been agreed to by the committee of the American Steel Plate Association.

The bending test in the Massachusetts law is the same as ours, except that they allow no limit of thickness, but expect plate of any thickness to be bent down double on itself. This, we believe, will have to be modified for very thick plates, such as are used in the marine boilers.

The Massachusetts rules go into much more detail than our specifications, as note the following on page 4, par. 5:

	Pounds.
Iron rivets in single shear	38,000
Iron rivets in double shear	70,000
Steel rivets in single shear	42,000
Steel rivets in double shear	78,000

giving the maximum shearing strength of rivets per square inch of cross-sectional area. On page 5, par. 8, they give a table showing net area of segments of flat heads to be stayed, and in par. 9 the formula from which this is computed.

They give on page 6, par. 2, a table of areas of grate surface in square feet for spring-loaded safety valves. This differs slightly from the present rule of the steamboat inspection service. First: it is figured for a greater variety of pressures, and then the formula is slightly different from the Government formula, using a constant of 770 in place of 747, which gives slightly larger grate areas per square inch of safety valve area.

Important provisions in regard to the connections of safety valves in boilers are also given. Cast iron is prohibited for discs and seats, and no safety valve may exceed 5 inches in diameter. Valves are provided for on every steam outlet from a boiler, except safety valves. This is a great element of safety for boiler repairers; therefore much to be commended.

The factors of safety prescribed are somewhat higher than those of our specifications. Where ours run from 4½ to 5, the Massachusetts rules exact from 5 to 6, according to various circumstances. Boilers are rated at 3 horsepower per square foot of grate area, which is very low for present conditions of steam making, and would be true only where low grades of anthracite are used. With good bituminous coal 7 horsepower per square foot of grate area is the general practice. The hydrostatic test is fixed at 50 percent above working pressure, as against one-third excess by the A. B. M. A. rules.

Excellent examples are given for the efficiency of joints, running as follows:

	Percent.
Single riveted lap joint	0.576
Double riveted lap joint	0.739
Triple riveted, double butt strap	0.829
Quadruple riveted, double butt strap	0.937

Allowances are fixed for variation in weight of plates ordered by weight and those ordered by gage. Stamping the plates in five places is prescribed, but as the rules require only one such stamp to show on each plate, probable modifications of this may be expected.

The curious anomaly is seen in permitting open hearth flange or boiler steel for the combustion chambers and furnaces, and prohibiting it for shells, drums and butt straps. This provision was explained to your chairman as being a temporary one, the intention being to eliminate open hearth flange or boiler steel altogether from boilers, and insisting on the use of firebox and extra soft steel.

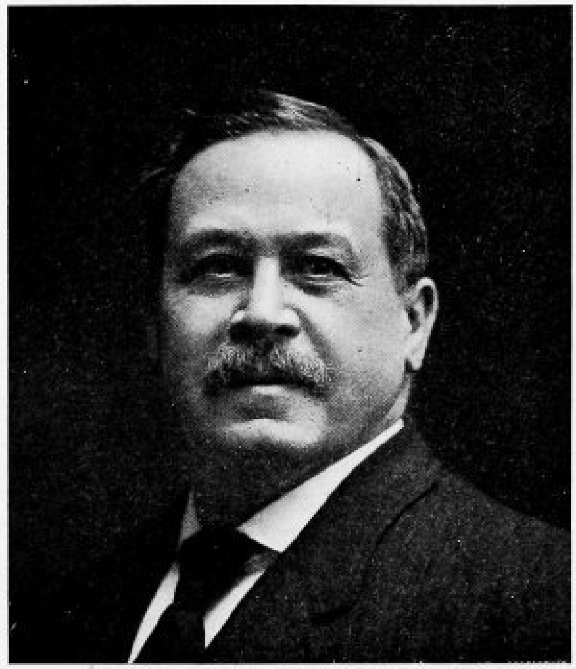
Cast steel is given more prominence than it deserves, as any boiler manufacturer, who has suffered loss from the porosity of steel castings, will agree. Cast iron is eliminated from boiler work in a number of parts, and wrought or cast steel specified so that the best practice will soon leave wrought steel only.

Pressure parts of superheaters must be steel. All boilers built or imported into the State of Massachusetts after May 1, 1908, must conform to these rules, and must be stamped "Massachusetts Standard," with a running number for each shop.

The staying of the exposed portion of flat heads of horizontal tubular boilers is very carefully prescribed, and examples given for small heads. The limit of length of a longitudinal joint is fixed at 12 feet. This is a good provision, as was shown by the tests of standard steel drums tested by your committee in Chicago in 1893.

A provision that the thickness of plates in the shell or drum shall be of the same gage is objected to by the builders of wagon-top boilers, but it is evident that this means only the same thickness for the same diameter, so that modifications would be permitted.

An excellent proviso, in the opinion of your committee, is that limiting the diameter of externally fired boilers to a maximum of 84 inches. On page 29, par. 15 gives the minimum thickness of butt straps, and par. 16 prescribes that butt straps shall be rolled to the proper curvature on forms made



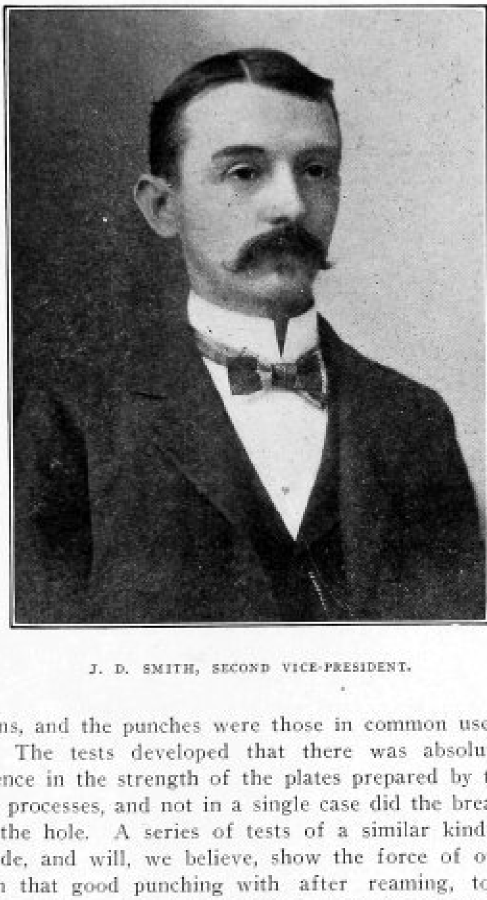
T. M. REES, FIRST VICE-PRESIDENT.

for that purpose. The pitch of staybolts, and the stress permitted on them is very carefully defined, and the better materials given the proper advantage.

A good provision is that increasing the thickness of a convex or a concave head by ⅛ inch when it has a manhole opening.

On page 36, pars. 36 and 40 give very stringent provisions for the drilling of rivet holes and tube holes. These contradict our uniform specifications in regard to rivet holes and tube holes in plates ⅝ inch and under, and are not in accordance with the general good practice in the United States. Your chairman discussed this with the chairman of the board of boiler rules at some length. The reason assigned for the stringent provision was that some shops might use inferior materials and dull punches, and therefore there would be danger of incipient cracks forming in the material in the process of punching. Exactly the same provision is found in the latest rules of the steamboat inspection service, and was probably inserted there from their experience with poor materials and poor workmanship, and therefore it would seem that this question should be determined by a series of experiments. It is well known that for the past forty years the builders of locomotive boilers have punched their tube holes, and it is almost universal practice to punch rivet holes for land boilers. While it is true that the drilling of the holes makes a slight additional expense, that need not cause any opposition to this rule. But it is a fact that much more accurate work can be done, both in rivet holes and in tube holes, by punching and then reaming, than is possible on a drill press. For drills have a fashion of running out, as we all learned in our apprentice days. Accuracy of work in modern boiler practice is very essential, and for this reason punching should not be thus condemned.

Your chairman made a series of tests, covering two samples each of large holes punched simply, punched and reamed, punched, reamed and annealed, and drilled with the cutting drill. These samples were simply marked for identification and submitted to a well-known and conscientious expert for test, with the distinct understanding that he should not be told how the holes had been prepared until after he had made his tests and completed his report, and he agreed not to examine them critically, with a view to determining for himself. The object was that he should make the test and report entirely without bias. The steel chosen for these experiments was A. B. M. A. steel, perfect as to all speci-



J. D. SMITH, SECOND VICE-PRESIDENT.

fications, and the punches were those in common use in the shop. The tests developed that there was absolutely no difference in the strength of the plates prepared by the different processes, and not in a single case did the break start from the hole. A series of tests of a similar kind should be made, and will, we believe, show the force of our contention that good punching with after reaming, to make smooth surfaces and remove burrs, is first-class workmanship for boilers.

Your committee believes that the closest scrutiny and tests of the materials which go into the boiler are of prime importance, and that a material which has to be so gingerly treated that it cannot be punched with safety is not fit to go into a boiler at all.

The board of boiler rules of the State of Massachusetts has for its chairman the chief inspector of the Boiler Inspection Department of the State, and the other members represent respectively, boiler using, boiler manufacturing, boiler insurance interests and operating engineers. They have covered many points and done excellent work in the preparation of these rules, and have always been ready to weigh and consider the merits of all reasonable suggestions coming from boiler manufacturers. We believe that they will be ready to continue to improve and modify their rules, with a view to making them the best that have ever been formulated. The natural consequence will be the adoption of these rules by other States, and a gradual but sure approach to uniformity in boiler construction throughout the country.

In this we ought to co-operate, and your committee suggests to every member to supply himself with a copy of these rules, which will be gladly furnished by application to Mr. Joseph H. McNeill, chief inspector of the Boiler Inspection Department, 15 Ashburton Place, Boston, Mass.

We further believe and recommend that your committee should be instructed to place themselves in communication with the commission on revision of laws relating to safety of life at sea, as appointed by President Roosevelt, so that our experience in the matter of boiler construction may be given weight in the revision of these laws.

Very respectfully submitted,

E. D. MEIER, *Chairman,*
THOS. M. REES,
H. J. HARTLEY,
GEORGE N. RILEY.

Exhibits to Report of Committee on Uniform Specifications.

A.—Commission on Revision of Laws Relating to Safety of Life at Sea.

WASHINGTON, D. C., June 2, 1908.

Sir—Your attention is called to the following Executive Order of the President of the United States:

EXECUTIVE ORDER.

The following named gentlemen are designated as members of a commission, hereby created, to examine the laws of the United States for the better security of the lives of passengers and crews on board vessels of the United States, with a view to their revision and to recommend to me such changes as in their judgment the public interests seem to require:

Captain Adolph Marix, U. S. N., Chairman of the Lighthouse Board, Chairman.

Hon. Charles Earl, Solicitor of the Department of Commerce and Labor.

Hon. Eugene T. Chamberlain, Commissioner of Navigation.

Hon. George Uhler, Supervising Inspector-General, Steamboat Inspection Service.

Commander William Strother Smith, U. S. N.

THEODORE ROOSEVELT.

The White House, May 12, 1908.

You are invited to make such suggestions and comments as your experience prompts, and as in your judgment should be brought to the notice of the commission, treating each subject in a separate communication.

It is desired that your views be expressed in writing, and that you state whether it is your wish to appear before the commission in person.

By Order of the Commission,
W. STROTHER SMITH, *Commander, U. S. N., Member and Acting Recorder.*

B.—An Act (Chapter 465, Acts of 1907, Commonwealth of Massachusetts) Relative to the Operation and Inspection of Steam Boilers.

See page 254, August, 1907, issue of THE BOILER MAKER.

C. Rules Formulated by the Massachusetts Board of Boiler Rules in Accordance with the above Act.

See pages 324, November, 1907, and 107, April, 1908, issues of THE BOILER MAKER.

D.—Report of Committee on Uniform Boiler Specifications of the American Society for Testing Materials.

NEW YORK, June 10, 1908.

TO PRESIDENT AND MEMBERS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS:

Your committee "R," to whom you have given the duty of reporting on uniform boiler specifications, beg leave to report as follows:

In view of the fact that boilers, as objects of inter-State commerce, are sent from any one State into any other, the necessity of uniform rules in boiler construction is apparent. The American Boiler Manufacturers' Association has since 1879 made many attempts through zealous members in several States with the co-operation of its committee on uniformity, to pass laws governing rational construction of boilers. In every case they failed through opposition of some local interest. Their next move was in the direction of improving and unifying the boiler rules of the steamboat inspection service, in the belief that the larger cities, situated on navigable waters, would naturally copy these rules and embody them in their ordinances, if they were made to conform to best modern practice. Recognizing that the demands of an increasing inter-State commerce would make uniform laws a necessity, they cherished the hope that under the inter-State commerce clause constitutional warrant might be found for Congressional action. At the same time they gathered extensive information in regard to best American boiler practice and embodied it in their uniform American boiler specifications, which represent persistent work on the subject from 1889 to 1905. Experience proved the great educational value of the rules therein laid down, by their adoption in many engineering specifications.

In 1907 the Legislature of the State of Massachusetts adopted an act relative to the operation and inspection of steam boilers. Under this act a committee was appointed, representing boiler using, manufacturing and insurance interests, and operating engineers, *i. e.*, all the classes immediately dependent on good boiler practice. This board of boiler rules was presided over by Mr. Joseph H. McNeill, chief inspector of the Boiler Inspection Department of the State of Massachusetts. The wide experience and intelligent study brought to the task by this board have resulted in a set of rules, published March 24, 1908, which cover every phase of the subject.

The adoption of these rules by a State always noted for the high intelligence of its people, and one whose interests are mainly manufacturing, marks a decided advance in the movement for uniform boiler specifications. As one of the members of our committee fairly puts it: The rules are somewhat drastic in some respects, but they represent mainly the best engineering practice of the day.

The chairman of your committee has had several meetings with the chairman of the board of boiler rules, and takes pleasure in testifying to the fair, intelligent and rational methods which govern the actions of the board. We believe that there is reason for the hope that these rules, modified in consequence of larger experience, will in due time be adopted by other States, recognizing the necessity of uniformity equally for engineering and commercial reasons.

The interest of our society in this matter lies in the question of materials. It is gratifying to report that the specifications for boiler steel are taken verbatim from the specifications of this society. There is, however, ground for criticism in the chemical properties prescribed.

For flange or boiler steel the percentage of phosphorus is limited to .06 percent for acid and .04 percent for basic, and for extra soft steel, .04 percent for acid and .04 for basic.

The question arises: What peculiar advantage has the acid over the basic process of making steel so that a higher percentage of phosphorus may be tolerated in the former than in the latter? We believe this to be erroneous. It was probably adopted because it was known to be more difficult to reduce the percentage of phosphorus below a certain limit in the acid than in the basis furnace. There certainly is no proof that failures from excessive phosphorus would be less in acid than in basic steel. And as comparatively few steel plate manufacturers now use the acid process, it seems timely to change this by making the maximum limits equal for the two kinds of steel. Furthermore, we cannot see any reason for allowing a higher percentage of phosphorus in extra soft steel than in the firebox steel.

We believe that no steel plate should be allowed to go into a boiler which has more than .04 percent phosphorus. The percentage of sulphur is limited in the three kinds of boiler plate mentioned, to .05, .04 and .04. These limits we consider too high. Your chairman's experience shows that

W. A. BRUNNER, THIRD VICE-PRESIDENT.

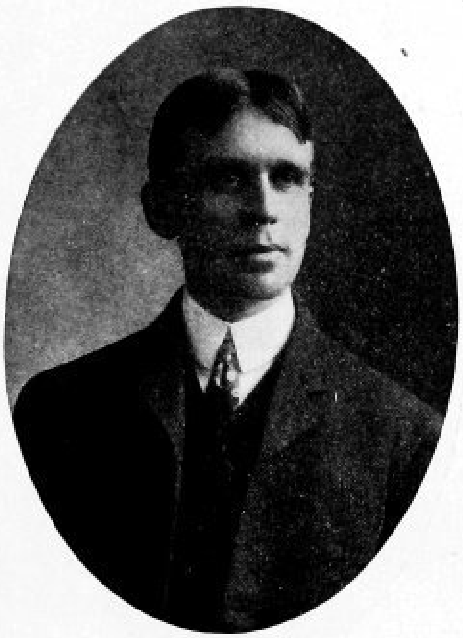
we cannot safely employ a boiler steel having more than .03 percent sulphur.

At most the specifications of the American Boiler Manufacturers' Association reached by agreement, after a long discussion by their committee and that of the Plate Manufacturers', should govern. These call for respectively, .04, .035 and .035 percent of sulphur. They were the result of a compromise, the boiler manufacturers very reluctantly conceding more than .03 percent. This upper limit of .03 percent had governed on A. B. M. A. steel from 1889 until 1905, and there never was any difficulty in getting plate with such low sulphur. In fact, experience shows that fixing .03 percent as the upper limit resulted in steel having much less sulphur, by the very natural desire of first-class steel plate manufacturers to remain well inside the danger limit.

A veteran inspector of most extensive and successful experience writes us that crystallization has developed quite rapidly with boilers operated at the higher pressures demanded by modern steam practice. The Massachusetts rules attempt to meet this by abolishing lap joints and insisting on higher factors of safety. As a temporary expedient this is excellent. But if a material is poor or inappropriate, merely increasing its quantity is not a final or rational cure. Its quality must be improved. If steel makers could meet the necessities of the automobile builder by furnishing axles and braces of 120,000 pounds tensile strength, they will certainly rise to the demand of the vastly more extensive steam boiler industry by eliminating the noxious metalloids and preventing their segregation. For uniformity in construction we must have uniformity in materials.

Experience in various widely different kinds of manufacture warrants the belief that in all of them success depends more on carefully selected and tested materials than on manufacturing methods, machines or mechanical skill.

In discussing various demands of these Massachusetts rules, covering designs and methods more exacting and difficult than the average good shop practice of American boiler works, our criticisms were met by the experience of the inspectors as to lack of quality and uniformity in plate and tubes.



H. D. MCKINNON, FOURTH VICE-PRESIDENT.

Our own experience coincides with theirs. While undoubtedly our plate and tube mills can make better materials than ten years ago, the unprecedented demand for quantity has made quality uncertain. But on quality the continued success and growth of our manufactures will always rest.

The Massachusetts rules committee has reposed absolute confidence in our society by adopting our specifications for materials. These rules will undoubtedly be widely quoted and in time adopted by other States and thus lead to uniformity. The responsibility resting on us as the originators of the steel specifications thus becomes increasingly grave. Your committee, therefore, deems it of the utmost importance that they be revised and modified on the lines above indicated.

Respectfully submitted,

E. D. MEIER, *Chairman*.

In introducing this report, Col. Meier called attention to the value of proper legislation on these subjects to all boiler manufacturers, no matter in what territory of the United States they may be situated, or of what class of boilers they make a specialty. He showed how it was of the greatest practical value to manufacturers to know just what they would be called to bid upon, and how when the inspection of land or stationary boilers is subjected to the same uniformity of operation as is the case with marine boilers or will be when a proper revision of the marine laws is had, the result will be that unscrupulous competition will be impossible, and all will have to live up to the same requirements and comply with the law. It is sometimes asked by some manufacturers, "How am I affected by regulations applying to the character of boilers that I myself do not manufacture?" But the speaker showed that all departments were in a measure interdependent, and the building up of a proper sentiment in support of laws for the protection of life and property by insuring safe boiler construction would help every manufacturer. The Massachusetts law will undoubtedly be used as a model in many other cases far distant from that State, and in cities and States where at present no similar legislation may have been enacted. Even where such legislation may not be accomplished, yet private investors who may be using Eastern capital will voluntarily adopt similar specifications. Thus the character of legislation adopted in any State is a subject of mutual interest among manufacturers of other States.

The report was received and the committee continued, with a vote of thanks, and such was the appreciation of the value of the report that on motion of Mr. Connelly, of Cleveland, a special edition in advance of the regular printed proceedings was ordered to be printed and distributed at an early date. It was also suggested that copies of the Massachusetts law be circulated among manufacturers of boilers generally.

In discussing this report, Mr. Stewart called attention to the fact that the Board of Boiler Rules of Massachusetts had made a provision that no boilers can be constructed over 84 inches in diameter, but a protest being made by the manufacturers of horizontal tubular boilers a modification of the ruling was obtained, referring to externally-fired boilers.

Mr. Wilkinson, in connection with pressure on horizontal tubular boilers, stated that in Oswego, N. Y., specifications had been drawn a short time ago for three boilers 84 inches diameter, 18 feet long, to carry 160 pounds working pressure. The speaker held that if the diameter is to be limited there should also be a limit placed on pressures, and that 160 pounds on a boiler of that type is exceeding the safe limit. Being asked by Mr. Scannel what the thickness of the shells was, the speaker replied that that was left to the option of the manufacturers. In his opinion such boilers should be built of plate of not less than 9/16 inch thickness. Three years ago he had built boilers of 84 inches diameter, under Hartford specifications, plates not less than 9/16 inch thick, working pressure 150 pounds. The concern for whom they were intended was not actually using over 100 pounds pressure in its other boilers, and the engines were not adapted to pressures above that; yet the owners insisted on the new boilers being 150 pounds pressure, in order that as the boilers got older they might have more leeway for the reduction of pressure on inspection. As a result, the boilers having to be made in three courses, the circular seams near the bridge, the hottest part of the fire, were of such thickness that, together with the poor quality of the water used, after the boilers had been in commission six months the plates commenced to open on the girth seam near the bridge wall, and it cost some $1,100 to make the necessary repairs. The pressure had to be cut down as a consequence. In his part of the country, the speaker said, the paper mills that carry a high pressure with this type of boiler experience much trouble. There is a great deal of salt, magnesia and lime in the water, and it is almost an impossibility to keep the boilers in condition. Although strict directions are given to owners to wash the boilers thoroughly every week it is impossible to keep down the scale.

Mr. Scannel asked if scale collected more quickly on 5/8-inch than ½-inch plate. The speaker replied that it would depend on conditions; he had seen scale collect more quickly on 7/16-inch than 9/16-inch plate.

Mr. H. J. Hartley, of the Wm. Cramp & Sons Ship & Engine Building Company, of Philadelphia, read a very valuable paper, entitled "Necessity for Uniform Laws Covering the Construction and Inspection of Boilers."*

The speaker stated that in presenting the paper to the association it was not with the object of presenting anything new in the manufacturing of boilers, but merely to present for consideration and discussion the importance, feasibility and necessity of urging the enactment of national uniform boiler inspection laws as a compulsory means of preventing, as far as possible, or at least minimizing, the loss of human life and destruction of valuable property, resulting incidentally, from accidents to steam generating apparatus; said laws when enacted to provide for a uniform inspection of all steam boilers in use on land throughout the United States, and to be enforced similarly to the rules governing the marine or steamboat inspection service, which is now under the Department of Commerce and Labor. The paper takes up the following heads: A résumé of the general construction and operation of boilers, including the quality of workmanship and class of materials entering therein; the care exercised in their usage with regard to safety after installation, such as ample facilities for proper maintenance and guarding against liability to accident and general explosions; also the present mode of inspecting boilers by insurance company inspectors and officials of local inspection laws during the course of construction and thereafter; the mode of applying hydrostatic test to new boilers and to old boilers, and, lastly, the effectiveness of the present mode of boiler inspection in general as practiced throughout the country.

In connection with this paper, Mr. Hartley showed photographs showing the condition of a boiler which had been passed under hydrostatic test, yet which was half full of scale, completely choking up all of the water space in the lower half of the boiler.

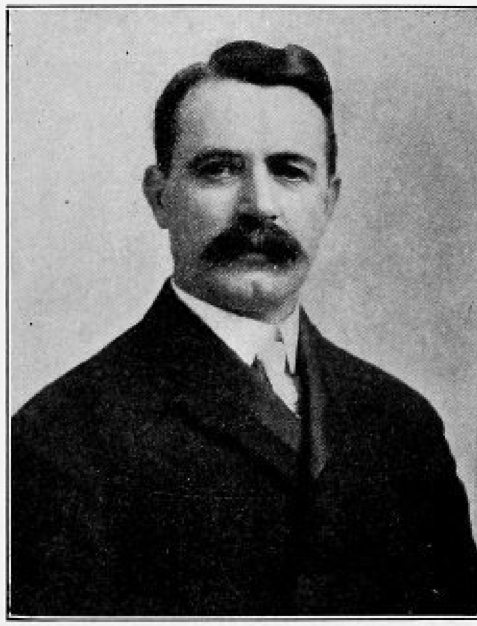
A vote of thanks was tendered Mr. Hartley, and 1,000 copies of the paper ordered printed for distribution in advance of the regular proceedings of the convention.

In the discussion following, Mr. Hirsch, representing the Carnegie Steel Company, said that the steel manufacturers wished to co-operate with the boiler manufacturers in every forward movement that had for its object the conservation of life and property and the production of the highest steam economy and efficiency. He referred to the supposed conflict of States rights with the theory of federal government, and maintained that if individual States differed, and one was right and the other wrong, there should be some superior authority to decide. Suppose that each State of the forty-six should establish a different law, it would be impossible for manufacturers to conform to them all, and the result would be most deplorable. The boilers of the American manufacturers should be like the money of the nation—current all over the world and good everywhere. He advocated collecting the various laws of all the States, examining them carefully, and selecting a model law for adoption by the federal government as a common standard, to which in time all might be brought to conform. He asserted that the manufacturers of steel would do their part to bring about the grand result. Compulsory common school education has in practice been found to be a good thing, and compulsory boiler inspection will be found to be equally good for all concerned, both the makers and the consumers and the great public whose lives are endangered by faulty construction.

*See page 264.

Mr. Rees hoped that the recent commission appointed by the President would recommend a general federal law governing the construction and inspection of land as well as marine boilers.

Mr. Wilkinson spoke of the uniform laws abroad, in the countries with which he was familiar, viz.: Germany, the Dutch East Indies, Italy and Holland, where the law was uniformly applied throughout every town and hamlet and with no uncertainty or indefiniteness. He had built boilers for those countries, having provided himself with the laws, and had them translated. He had no difficulty in meeting the requirements, and had never had a boiler rejected for lack of compliance with the government regulations. He was opposed to the inspection of boilers being relegated to the police department, as in New York City, when captains of



J. D. FARASEY, SECRETARY.

police might be called on to pass upon a subject about which they knew practically nothing.

On motion of Mr. Bate, the committee on uniform specifications was instructed to use all efforts in their power to bring about greater uniformity of State laws relating to this subject.

Mr. George Hartley made some remarks from the point of view of the large buyer, being connected with a plant having throughout its jurisdiction some 260 or 275 boilers scattered through different parts of the country from Alabama to Michigan, having in one plant in New York some 110 boilers. They had found much confusion existing between specifications in vogue in different localities, and this resulted in an equal confusion between different bidders when manufacturers of different localities competed for certain work. Fortunately, the concern employed a competent engineer who was able to go over the specifications and bring order out of chaos. A smaller concern might not be able to do this as easily, and hence the advantage which the general public would derive from general laws on this subject.

An instance was related by one member where it had come to his ears that a competitor had asked the steel company to mark the steel one grade while selling him another. Mr. Hirsch declared that that was a thing which he knew his company would never do, and he did not think others would.

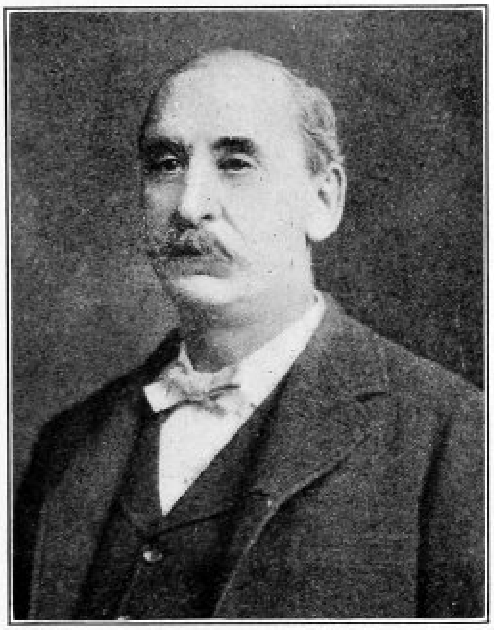
It was then explained that the steel company in question had also refused to do this.

WEDNESDAY AFTERNOON SESSION.

At the Wednesday afternoon session, Detroit, Mich., was selected as the next convention city, and the following officers elected to serve for the ensuing year, viz.:

President—E. D. Meier, New York, N. Y.
Secretary—J. D. Farasey, Cleveland, Ohio.
Treasurer—Jos. F. Wangler, St. Louis, Mo.
First Vice-President—T. M. Rees, Pittsburg, Pa.
Second Vice-President—J. Don Smith, Charleston, S. C.
Third Vice-President—W. A. Brunner, Phillipsburg, N. J.
Fourth Vice-President—H. D. McKinnon, Bay City, Mich.
Fifth Vice-President—M. A. Ryan, Duluth, Minn.

Mr. Champion, of the Champion Rivet Company, Cleveland, Ohio, being called upon to make some remarks regarding the welfare of the association, responded with a forceful



J. F. WANGLER, TREASURER.

address, replete with valuable suggestions, and incidentally told the manufacturers something about how to make the best use of Champion rivets as well as other steel rivets. Wrong methods are often responsible for complaints as to rivets, which never would arise if rivets were properly handled; his caution was never to drive a rivet except on a rising heat, and to finish it before it becomes a dark blue heat. If this advice is adhered to in practice no trouble will be experienced with rivets made of the right quality of steel.

Col. Meier asked whether it would be possible for the rivet manufacturers to determine and advise their customers as to the highest possible heat that a rivet would stand. As there are now many practical devices for maintaining a certain fixed maximum temperature this knowledge could be put to good use.

Mr. Champion stated that he had never instituted such experiments, but he emphasized again the fact that rivets must be worked while they are "coming, not while they are going." Mr. Hartley corroborated this statement from his experience, stating that if you take a piece of boiler sheet and put it in the fire and heat it from a slight heat up to blue heat you can flange it, but if the same piece has been heated up to regular flange heat, and then allowed to fall back to blue heat, it will in all probability break. You can do anything with steel on a rising heat, but not with a falling heat.

Mr. Wilkinson called attention to a new device patented by Borgel & French, York, Pa., called French's Interlocking Rivet Joint, which it is claimed will make the joint absolutely tight, making it unnecessary to calk. The speaker said that he had not sufficiently investigated the matter to pass an opinion on it. It was claimed that a boiler subjected to a hydrostatic pressure of 500 pounds showed no leakage by the use of this process. Referring to the matter of smoke nuisance, the speaker said that he believed it to be the province of the boiler manufacturers to take progressive ground on this matter, and to aid all in their power to discover some device that would remedy this trouble of smoke. He suggested that the Dutch oven might be used as a groundwork for a practical solution of the trouble. Boiler manufacturers are designing boilers all the time; why should they not design something to go along with them that would remedy the smoke nuisance? The speaker contended that the present automatic stokers do not meet the situation sufficiently. The speaker further alluded to the subject of adopting some standard depth from the grate line to the shell in boiler fronts with horizontal tubular boilers, especially where bituminous coal is used for fuel. The majority of manufacturers make their fronts so that the grate line will be on a level or within two feet of the shell of the boiler, so as to reduce the cost of the front; they do not want to give the purchaser more metal than necessary. The speaker held that with the majority of the Pennsylvania coals used this distance is not enough. In two boilers recently installed of 200 H. P. each, the old boilers replaced had only 26 inches from the grate line to the bottom of the shell; this was increased in the new boilers to 40 inches, it being impossible to make it any higher and allow room for the steam piping. The difference in the amount of smoke made and the pronounced saving in fuel was striking. The speaker thought that 48 inches would have given still better results. If this is a decided improvement all manufacturers of boilers should adopt and recommend it, and they are the ones to take the forward step.

Mr. Corbett, at the request of Mr. Riley, spoke generally on the subject of increase of membership, and made some good suggestions.

Mr. Brunner stated that the country members had opposed the adoption of a proper boiler inspection law in his State, but Mr. Corbett thought they could be converted if shown the error of their ways in a right spirit. The boiler inspection laws should be made to apply generally throughout the States, instead of being confined to the larger cities.

Mr. J. Don Smith, of Charleston, S. C., stated that he had recently read an article in a mechanical trade paper referring to trouble experienced, which he had also found to exist, as to closing holes in hollow stay-bolts during the riveting process. He asked for light on this from those present who were making marine boilers or locomotive boilers.

Mr. Meier stated that they used a larger hole, say .88 inch, and put a plug in while riveting, and removed same afterwards. It is sometimes found necessary to pass a reamer through. Mr. Smith asked if the plug would upset? Col. Meier replied they had not found it so; set an air tool on it, and the little burr that may form inside is removed with a reamer. Col. Meier also spoke of the opposition to boiler inspection law by farmers running traction engines and threshing machines, and also in the oil regions from those using small power plants.

Mr. Farasey suggested that if the committee on uniform boiler specifications were recognized fully by the new commission it would have a good effect in clarifying the atmosphere generally, and render the campaign for general and uniform laws more effective in results.

Mr. Wilkinson took strong ground along the line that the federal government has full authority to enact legislation compelling uniform inspection on boilers when objects of inter-State commerce, and did not believe the statement that the matter of States rights would prevent the passage of such a law by the United States Government. It is necessary to have a general federal law, as it is impossible to expect uniformity among State and municipal governments with their opposing local interests and political complications.

There was an opinion on the part of some present that such a law might be in opposition to States rights and as such unconstitutional. Col. Meier appeared to be of this opinion, and therefore urged the greater necessity for general agreement and effort among all boiler manufacturers in order if possible to harmonize and unify various State laws. If the weight of the influence of the new commission could be thrown in favor of uniform boiler inspection it would help greatly.

Mr. Wilkinson thought if general banking and currency laws were matters of federal legislation, that boiler inspection laws which had to do with precautions to protect human life should also be looked after by the general government; banking laws only protected financial interests, but boiler inspection would save human life as well as property.

Col. Meier thought a test case would have to be taken to the Supreme Court under the inter-State commerce clause of the United States Constitution.

Mr. Connelly did not think federal control could be had over land boilers, instancing the fact that oil inspectors were appointed only under State laws, as well as fire marshals. If the commission could be brought to revise the marine boiler inspection regulations, then the ultimate effect would be that cities and States would follow in their lead.

Col. Meier said that the action of the commission in this direction if favorable would give great impetus to an educational campaign throughout the country generally in the various States. He suggested that this would be a proper matter to have brought up before the next conference of governors, and enlist their co-operation, and stated further that he intended to bring the matter to the attention of the President of the United States.

Mr. Rees felt sure that if the governors of the various States could be enlisted in the movement and given the assurance that all the boiler manufacturers desired it done, it would have a great effect.

Mr. Wangler, of St. Louis, referring to the subject of membership, suggested the formation of more local organizations as a valuable auxiliary to the work of the national. The chair replied that provision for that had been made in the constitution of the association, but it had rarely been attempted.

Height of Stacks.

The question of relative height of boiler stacks to suit different altitudes was discussed by Messrs. Wilkinson, Meier, Connelly and Hartley, and some interesting experiences related. It appeared that in shipping to high altitudes some of the speakers had miscalculated and underestimated the necessary addition to ordinary height at sea level made necessary at the higher altitudes. Both the grate area and the horsepower must be taken into consideration, as well as the desired altitude. In Europe, Mr. Wilkinson incidentally remarked, boilers are sold not by horsepower but by the amount of water evaporated at a given temperature. Col. Meier's rule would, roughly speaking, add about eight percent to the height of the chimney for every 1,000 feet of altitude. Enlarging the area will not answer unless the necessary height is obtained. The area may be increased in the same ratio that you would decrease the square root of the height of stack. Mr. Wilkinson related an amusing experience where proper draft could not be obtained, and it was only after great difficulty that he could induce the boiler user to cut an opening into the boiler room, so as to permit the introduction of sufficient air to supply the draft, without which no height of chimney could have availed. Mr. Connelly, in sending some Scotch boilers to Salt Lake City, Utah, increased the stack area 20 percent and the height 33 percent over that at sea level, and had received excellent reports from the boilers.

Mr. Hartley asked which was better, a round or a square stack, and Mr. Wilkinson replied that a round stack was the most perfect shape. Col. Meier pointed out the necessity of having the openings under the grate large enough to admit the necessary air for the increase in height. Mr. Wilkinson said that with a boiler developing, say, 200 H. P., and requiring ordinarily a stack 100 fet high, natural draft, with forced draft would require a stack only 65 feet high. This would give better results than one 100 feet high. In Pittsburg, in the case of boilers developing 950 H. P., two stacks took care of four boilers, with induced draft, the stacks being 135 feet high. This was found to be too high, and they had to be cut down to 90 feet. They could not be made any lower because of the method of construction of the stack. The fans were taken out and more horsepower developed than required. The minute you commence to use forced draft with a very high stack, you are forcing a larger volume of air into the stack than it is able to carry, and the gases become chilled.

Mr. Connelly told of a fireboat where the stack was found to be too large in diameter to raise sufficient steam to pump, which was remedied by a petticoat pipe slipped inside of the stack.

Mr. Hartley said that it was true you could get a stack too large, but as a general rule, mistakes were made the other way. For stationary work he recommended adding one-quarter to the area of the tubes for the size of the stack. Of course, surroundings will affect the ratio, high buildings or hills, etc.; but in steamboat practice the area of stack is generally one-seventh of the area of the grate surface, that is, for natural draft. Forced draft has upset all former theories as to smoke stacks; and there is a great difference between induced draft and forced draft, so that the stack business is a complicated problem.

Mr. Wilkinson said that consumers are very apt to overlook the necessity of taking the grate area into full consideration when estimating for stacks.

THURSDAY MORNING SESSION.

President Meier introduced Mr. John Overn, of Philadelphia, who was for many years boiler inspector for that city, and under whose administration the excellence of that inspection service was established. Mr. Overn carried it out so conscientiously that a standard was set which has since been maintained in that city far in advance of all others, in America at least.

The following new members were elected: E. M. Wilkinson, Oil Well Supply Co., Oswego, N. Y.; A. J. Schaaf, The Mon. Con. R. C. & C. Co., Pittsburg, Pa.; M. H. Broderick, Broderick & Quinlan, Muncie, Ind.

The meeting being now thrown open for suggestions relating to the good of the association, Mr. Bate, of Conshohocken, Pa., gave a history of the progress of the concern of Wm. T. Bate & Son and its adherence to original methods, so far as they proved effective even in more modern times. Mr. Bate is one of the original charter members of the A. B. M. A., and his account of the earlier days of the boiler industry was interesting. Owing to the larger facilities of many shops, the work of this concern is now largely confined to repair work; they do no marine work. He does not use many steel rivets and holds that iron rivets, properly driven, are better for his class of work, light and repair work. The rivet will upset better in the hole; it is softer. He preferred to punch with a rack. A great deal of poor work is done in boiler shops on account of defective holes, and this is avoided by punching with a rack. His firm had never had a single boiler made by them explode during all their career. He uses plate from .47 to .38 gage.

The speaker believed that too many boiler manufacturers have neglected to post themselves as to what the A. B. M. A. has done for them and for the industry generally; if this were better understood more manufacturers would join the association. Many of the smaller shops especially, and some of the larger ones, seem to think that entertainment is all that the conventions are held for; while the fact is that much good work has been done in the past and more will be done in the future with the help of those who are now on the outside. With regard to driving rivets properly, the speaker said that his practice had always been to drive at a white heat, but many do not heat them that much. The trouble in doing hand work now is the difficulty of getting properly trained skilled men. It is, of course, more expensive to do hand work rather then to use the machines. The speaker preferred iron to steel tubes provided they could be had at the same price; he did not think that there had been any improvement on tubes.

Mr. Riley told of an instance where, when the National Tube Works were about to build a rolling mill in 1877, they built for Capt. Jones three boilers of Bessemer steel, 48 inches diameter, 28 feet long and .28 shell, with five 12-inch flues, two below and three above. These boilers went into service and gave good satisfaction. The National Tube Works built 12 boilers of the same size and same style which gave good service for 22 years, ordinary wear and tear excepted. The steel of which they were made when the punch went through it would make a noise like a gun shot. The speaker had never heard of any such being built since. In regard to tubes, the speaker said they are governed by the demands of the trade; the trade seems to be drifting at present towards steel. The United States navy has adopted steel; the railroads are all drifting into steel, both seamless and lap weld; the National Tube Works makes either charcoal iron or steel. If, as the previous speaker said, people that know anything about boiler making would not put in steel tubes, there must be a lot of people that do not know anything about boilers, because steel tubes are being largely used by competent people all over the world.

Mr. Rees stated that although he had been at one time known as a crank on iron rivets, he had been converted to steel, and had simply been astonished at the advances made in their quality and effectiveness. Among different rivets submitted to him for careful examination as to quality, he had been greatly astonished and pleased at the high character of the product. He commented especially favorably on the Champion rivets as equal or superior to any iron rivets he had ever driven. He had put steel into boilers, along with Col. Meier, as early as 1870. In 1869 he had put it into a repair sheet and the local board said he must take it out. In 1871 he received a contract for five boilers of crucible steel which were put in the steamer *Philip W.* in 1872; from that time on steel was employed in competition with iron. He showed a sample of steel plate, turned over with one blow, meeting all the requirements of United States steel, tensile strength 65,000 pounds per square inch.

Col. Meier said that when they used to use iron they did not get 45,000 pounds tensile strength.

Mr. Rees gave his testimony to the effect that he has been using flues of different makes, both iron and steel, lap weld and cold and hot-drawn seamless tubes, and never in all his former experience has he had flues as good as those he is using to-day of any of the makes of cold-drawn tubes. They will turn over without a solitary crack; so far as his experience goes, they are far superior to those of the old days.

Mr. Broderick, one of the new members, stated that his concern was manufacturing what is known in the oil country as firebox boilers, also traction engine boilers, of which they make a large number annually. They have not got a flange fire in the shop, do not know what it is; everything is machine. The boilers they build for the oil country require the most difficult flange there is, in the speaker's opinion, and they have not had a complaint to make regarding material in five years.

Mr. Aldcorn, appearing before the convention as the spokesman of the associate members, stated that they would co-operate in any efforts made at Washington to explain to the authorities there the needs of the boiler manufacturers generally, and they would render substantial financial assistance. On motion of Mr. Riley, the offer was accepted, with thanks, by rising vote.

Chairman Meier, after putting the vote and announcing the result, added his thanks to the associate members, and said that as soon as a time was arranged when the committee would appear before the commission at Washington, if an oral hearing could be arranged, the associate members would be notified, and a committee of three from their number requested to accompany the A. B. M. A. committee to Washington.

Col. Meier brought to the notice of the convention the recent death of Mrs. James Lappan, wife of one of the oldest members of the association, and past president, Col. James Lappan, of Pittsburg. On motion, a committee was appointed to draw up suitable resolutions of sympathy and condolence and forward the same to Mr. Lappan. The committee reported later, as follows:

The American Boiler Manufacturers' Association in Twentieth Annual Convention assembled adopted on July 16, 1908, at Atlantic City, N. J., by rising and unanimous vote this tribute of their affectionate sympathy and condolence to its esteemed past president, James Lappan, in the loss of his beloved wife, Mrs. James Lappan, and directed the same to be suitably engrossed, in an endeavor to convey to him that tender feeling of the heart which words cannot express.

Our hearts go out to our friend, James Lappan, in the sorest trial of his life. We know of his early struggles; but in these he had a helpmate, devoted, affectionate, untiring; doubling his courage by her unquestioning faith in him.

She saw with the clear eyes of love the success that would be his when to him it was but a dim vision of hope.

The innate chivalry of his nature rose at her touch, and his strength found opportunity in each new obstacle. The work he has done, the victories he has won, and above all, the manhood he has achieved, are all due to the sweet and noble lady he loved and cherished for a lifetime, but who has now gone before.

Her true womanhood will always be an inspiration to all who were privileged to know her.

We know that no words of ours can bring comfort to our friend; we can only hope that memory will in time supplant grief, and assure him of our earnest sympathy.

E. D. MEIER, *Chairman.*

Mr. Jas. G. Mitchell, of Philadelphia, related how the Standard Oil Company had saved thousands of dollars by using A. B. M. A. steel for bottoms to their oil stills, which previously had been made of firebox steel and the bottom cracked and had to be renewed after a very few runs, but with A. B. M. A. steel they had been known to make 2,500 runs without renewal, meaning a tremendous economy to a concern of the magnitude of the Standard Oil Co. They are perhaps the largest users of this material in the country to-day. Mr. Mitchell paid a compliment to Mr. Chas. Schwab, and also to Mr. H. J. Hartley, whose paper he had much enjoyed. Referring to the present state of the boiler manufacturing industry, Mr. Mitchell declared that the United States stands to-day in this line the peer of any other country in the world. The speed of our battleships compares with that of any, and this is due to the quality of their boilers as much as to anything else. He congratulated the convention upon the presence and co-operation of the progressive steel plate manufacturers of this country in attendance at the convention. While it was well enough to speak of the past, and what the conditions were then, yet the vital question is the present, and what we can do in the future that is ahead of us. It is because of the excellence of the product of the boiler manufacturers that steamships are to-day crossing the broad Atlantic in four and a half days, and the world expects them to still further surpass their past achievements, which they will do with the aid of the government in a speedy revision of obsolete laws, so as to make them fit the living present. Pure food laws have been enacted; why not take hold of the boiler question and let us have safe boilers and reduce the loss of life that must inevitably ensue under poor inspection or no inspection or supervision of an adequate character, suited to present conditions and demands? In conclusion the speaker prophesied for the future of the association continued and increasing usefulness along technical and dignified lines, such as will make the A. B. M. A. the equal of any organization in the country in its power for usefulness and benefit to the whole people.

Mr. Campbell, of the Jones & Laughlin Co., Pittsburg, Pa., added his contribution to the general testimony presented as to the progress of the steel plate manufacture in the United States, and asked to be enrolled in the ranks of the optimists, along with Mr. Schwab. The country has been suffering with a plethora of orders, and is having an attack of commercial indigestion, but times will soon get better, and we will all be better for it.

Mr. Champion suggested inviting the metallurgists employed by the boiler plate manufacturers to attend the annual meetings and contribute papers, a suggestion which was favorably received. The convention then adjourned sine die.

At the banquet Thursday evening Col. E. D. Meier, president-elect, was toastmaster, and responses were made by Charles M. Schwab, the guest of honor, and by T. A. Daly, James G. Mitchell, E. M. Wilkinson, F. M. Campbell, George Slate and W. O. Duntley. Mr. Schwab prophesied that 10 years hence steel production in the United States would treble the present figures. He referred to the co-operation now more common than ever among manufacturers, and said that the steel manufacturers of the country desired to treat all alike and see that the large buyer pays as much as the small one for the same product.

Mr. Slate, on behalf of the associate members and supply men, presented Mr. W. O. Duntley with a cut glass punch set in appreciation of his many years of faithful service as president of the supply men's association.

The associate members and supply men re-elected the following officers: W. O. Duntley, Chicago, president; J. T. Corbett, Chicago, vice-president; W. H. S. Bateman, Philadelphia, secretary; H. B. Hare, Cleveland, Ohio, treasurer.

The register showed the following members and guests present at the convention:

Miss Alice B. Chute, Youngstown, Ohio; Mr. and Mrs. H. B. Hare, Otis Steel Company, Ltd., Cleveland, Ohio; Mr. and Mrs. H. D. Mackinnon, Mackinnon Boiler & Machine Company, Bay City, Mich; W. H. S. Bateman and wife, Parkesburg Iron Company, and The Champion Rivet Company, Philadelphia, Pa.; G. T. Schnatz, Lukens Iron & Steel Company, Philadelphia, Pa.; C. L. Humpton, George Thomas III. and A. J. Williams, Parkesburg Iron Company, Parkesburg, Pa.; Miss Sue Crawford, Philadelphia, Pa.; Miss E. Woodruff, Philadelphia, Pa.; Mdme. Josephine Schimpf, Philadelphia, Pa.; H. J. Hartley, Wm. Cramp & Sons S. B. & E. Co., Philadelphia, Pa.; Bartholomew Scannell, Scannell Boiler Works, Lowell, Mass.; Misses Katharine and Mary Scannell, Lowell, Mass.; Mr. and Mrs. G. B. Hartley, and Howard Hartley, Syracuse, N. Y. (Solvay Process Company); Dr. John W. Scannell, Brooklyn, N. Y.; J. D. Farasey and wife, H. E. Teachout Boiler Works, Cleveland, Ohio; Geo. N. Riley and wife, National Tube Company, Pittsburg, Pa.; D. J. Champion and wife, Champion Rivet Company, Cleveland, Ohio; D. Connelly and wife, D. Connelly Boiler Company, Cleveland, Ohio; J. Don Smith, Valk & Murdock Iron Works, Charleston, S. C.; Alfred R. Jones, Robt. W. Smith and Henry J. Bailey, The Hilles & Jones Company, Wilmington, Del.; W. O. Duntley, Thos. Aldcorn, Geo. A. Barden and wife, Chas. Booth and J. W. Duntley, Chicago Pneumatic Tool Company, Chicago, Ill.; C. M. Schwab, chairman Board Bethlehem Steel Corporation, New York, N. Y.; Wm. L. Hirsch, Carnegie Steel Company, Pittsburg, Pa.; John J. Finnigan, J. J. Finnigan & Company, Atlanta, Ga.; Mrs. L. J. McGarry, Atlanta, Ga.; Mrs. J. P. DeHaven, Conshohocken, Pa.; Mrs. L. J. McLaughlin, Conshohocken, Pa.; Miss Alice Pennington, Conshohocken, Pa.; Jos. A. Wangler, Jos. F. Wangler Boiler & Sheet Iron Works Company, St. Louis, Mo.; T. M. Rees and wife, Jas. Rees & Sons, Pittsburg, Pa.; Robert S. Grove, Worth Bros. Co., Philadelphia, Pa.; Mrs. Mary F. Zippler, Philadelphia, Pa.; Geo. Slate and wife, The Boiler Maker, New York, N. Y.; L. M. Henoch, J. E. Ferguson and John T. Corbett, Jos. T. Ryerson & Sons, Chicago, Ill.; E. M. Wilkinson and wife, Oil Well Supply Company, Oswego, N. Y.; P. D. Millholland, American Iron & Steel Manufacturing Company, Philadelphia, Pa.; Jas. C. McHugh, Jenkins Bros., Philadelphia, Pa.; Chas. Shults and wife, Worth Bros., New York, N. Y.; Douglas A. Brown, official reporter, Cincinnati, Ohio; C. F. Lansing, The Globe Rolling Mill Company, Cincinnati, Ohio; Clifford M. Tudor, Tudor Boiler Manufacturing Company, Cincinnati, Ohio; A. J. Schaat, The Mon. Con. R. C. & C. Co., Pittsburg, Pa.; Wm. A. Brunner and wife, Tippett & Wood, Inc., Phillipsburg, N. J.; Mrs. Himes, Bethlehem, Pa.; Henry Becker, Philadelphia, Pa.; Jas. C. Stewart, Stewart Boiler Works, Worcester, Mass.; A. B. Scully and H. C. Finlay, Scully Steel & Iron Company, Chicago, Ill.; J. P. DeHaven, Conshohocken, Pa.; Geo. R. Bentley and wife, Central Iron & Steel Company, Harrisburg, Pa.; Miss H. L. Maule, Parkesburg, Pa.; John T. Rourke, Rourke's Iron Works, Savannah, Ga.; Eugene F. McCabe and James M. Spear, McCabe Boiler Works, Newark, N. J.; Col. E. D. Meier, Heine Safety Boiler Company, New York, N. Y.; Leonard Hartley and wife, Leeds, England; Hon. Franklin Stoy, Mayor of Atlantic City, N. J.; Mrs. Franklin Stoy; H. C. Broderick, Muncie, Ind.; Jas. S. Stirling, Wilmington, Del.; E. McDuffy, Marion Iron Works, Marion, S. C.; L. E. Geer, Manitowoc Dry Dock Company, Manitowoc, Wis.; Mrs. P. E. Milholland, Philadelphia, Pa.; L. J. McLaughlin, Conshohocken, Pa.; A. S. Mitchell, New York; H. H. Brown, The Boiler Maker, New York, N. Y.; A. J. Hamilton, National Tube Company, New York and Atlanta; R. R. Harris, Seamless Tube Company of America, Pittsburg, Pa; P. H. Furgeson, Seamless Tube Company, New York, N. Y.; W. R. Marsh, Seamless Tube Co., Chicago, Ill.; Mr. and Mrs. E. J. Mishler, Reading Iron Company, Reading, Pa.; L. G. Buckwalter and wife, New York Shipbuilding Company, Camden, N. J.; F. H. Megaw, Harlan & Hollingsworth, Wilmington, Del.; Mr. and Mrs. E. D. Giberson, National Tube Co., New York, N. Y.; Mr. and Mrs. Wm. J. Beury, Reading, Pa.; Irvin Bair, Kutztown Foundry & Machine Co., Kutztown, Pa.; Mr. and Mrs. Richard Wetherell, Robt. Wetherell & Co., Chester, Pa.; Wm. Nees, Elba Iron Manufacturing Company, Philadelphia, Pa.; John E. Lynch, Hodge Boiler Works, East Boston, Mass.; F. M. Campbell and wife, Jones & Laughlin Co., Philadelphia, Pa.; Mrs. A. J. Hamilton, National Tube Company, New York, N. Y.; John Overn, Philadelphia, Pa.; Frank Overn, Philadelphia, Pa.; Mr. and Mrs. M. F. Wilfong, Wilfong Bros., Philadelphia, Pa.; J. R. Bailey, Tyler Tube & Pipe Company, Philadelphia, Pa.; James Lynch, Du Pont Powder Company, Wilmington, Del.; Donald E. Campbell, Philadelphia, Pa.; Richard Bate, Conshohocken, Pa.; Archibald Johnson, Bethlehem, Pa.; M. Quinlan, Muncie, Ind.

How to Patch a Cracked Flue Sheet.

When a flue sheet cracks in the flange, as shown in Fig. 2, the first thing to do is to cut out the cracked piece as indicated by the dotted line. It will be noticed that it is necessary to cut through several of the upper flues. Therefore, before cutting out the cracked piece it is necessary to take out these flues and plug the flue holes. After preparing the patch and scarfing the laps, drill the rivet holes. It will be noticed that the rivet holes are so spaced that a rivet is placed on each side of the plug in the flue hole. This is done in order to hold the plug should it by any chance work loose. The details of the patch are seen in Fig. 1. It should be fitted up hot, and while some put it on with plug bolts hammered up on both ends, many prefer to use ¾-inch rivets, as it is easier to renew the riveted patch than it is one which is fastened with plug bolts.

The method of patching a hole in the center of the flue sheet is also shown in Fig. 2. This method can be used for patching the front flue sheet where the locomotive has been in a wreck and a hole has been punched in the flue sheet. The defective part should be cut out with a hack-saw, care being taken to remove all of the plate which is bent. After this, take a piece of sheet steel of the same thickness as the round head, and lay out and drill the flue holes in it to correspond with the flue holes in the part of the sheet which was cut out. The outside holes through which the patch is finally to be cut should be left full. After drilling, bolt the patch up to the round head where the piece has been cut out, and taking a scriber, mark the edge of the sheet where the old part has been cut out. Saw the patch out on this line, care being taken to make a good fit. After fitting the patch in place, hold it in place by putting bolts through the flue holes, with washers on each side of the sheet, while drilling the holes in the bridges in the same way as when plugging a cracked bridge in a flue sheet. Hammer the plugs up on each side, as shown in Fig. 2. This method can be used on a front flue sheet, but it cannot be recommended for a back flue sheet, as the fire may cause it to leak. It is a method which will save a lot of work, as otherwise the cylinders and smoke-box will have to come down, in order to cut out and renew the front flue sheet.

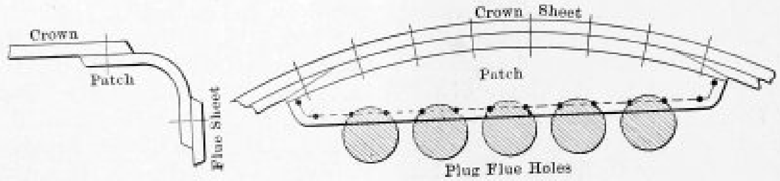


FIG. 1.

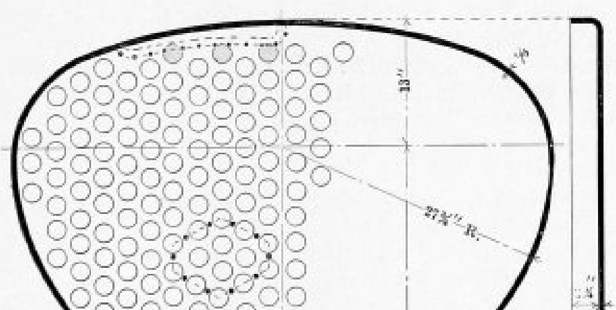


FIG. 2.

Necessity for Uniform Laws Covering the Construction and Inspection of Boilers.*

BY H. J. HARTLEY.

In reading this paper to the members of the American Boiler Manufacturers Association, it is not with the object of presenting anything new in the manufacturing of the product of the boiler industry, but merely to present to the association, for its consideration and discussion, the importance, feasibility and necessity of urging the enactment of national uniform boiler inspection laws as a compulsory means of preventing, as far as possible—or at least minimizing—the loss of human life and the destruction of valuable property, resulting, incidentally, from accidents to steam boilers and generators, said laws, when enacted, to provide for a uniform inspection of all steam boilers in use on land throughout the United States, and to be enforced similarly to the rules governing the marine or "steamboat inspection service," which is now working under the Department of Commerce and Labor.

As an inspiration of the idea of the vital necessity of having a national boiler inspection law, I wish to present to the members of our association a few remarks upon some general facts connected with boilers and their usage; a résumé of their general construction and the operating thereof, including the quality of workmanship and class of materials entering therein; also the care exercised in their usage, with regard to safety after installation, such as providing ample facilities for their proper maintenance and guarding against liabili-

* Read before the American Boiler Manufacturers Association of the United States and Canada at Atlantic City, July, 1908.

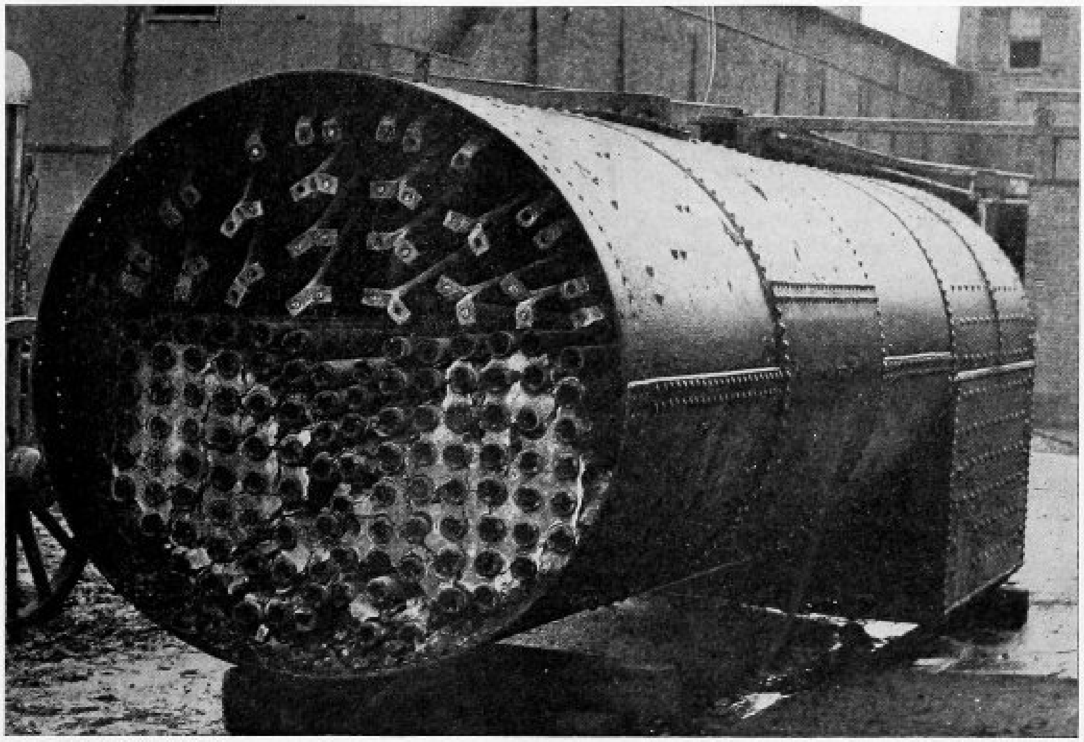
ties to accidents in all their details and to general explosions; also, the present mode of inspecting boilers by the inspectors of insurance companies and officials of local inspection laws during the course of construction and thereafter; the mode of applying the hydrostatic test to new boilers and to old boilers; and also the effectiveness of the present mode of boiler inspection in general as practiced throughout the country; all of which subjects are of vital interest to the boiler manufacturers, steam users and the general public, and could well be embodied in our annual list of topical subjects and discussed as such from a practical and technical standpoint.

Remarking upon the construction and efficiency of the steam generator of to-day, it seems that, owing to the essential fundamental principles the designers of boilers necessarily have in view, such as thermal values of different fuels, the maximum amount of heating surface contained within a minimum space necessary to economically absorb every heat unit contained in a pound of combustible, an efficiency in the different makes of boilers so nearly alike has been brought about that the selection of any particular design is largely based upon the experience the purchaser and operator have formerly obtained through the use of a particular type; while the inexperienced layman probably, too frequently, is governed in his selection solely by the cost. Those, however, who are critical enough to give the different types of boilers some study and thought before making a selection, by having before them drawings of such sectional views of each type as would permit of good comparisons, will be surprised to note their similarity, although known and sold under different names and patent rights.

In this connection I have in mind several vertical water tube boilers of the straight tube type, the only radical point of difference in which is in the arrangement of their baffle walls, directing the currents of hot gases. If these baffles were arranged in the three boilers precisely alike, it would be a difficult matter to distinguish one type from the other. This is also true of several of the so-called "inclined straight tube type"—the only difference being the method of closing the tube passage holes in their headers.

The efficiency tests submitted by the respective manufacturers of the different types of boilers are also nearly alike; each designer starting out to accomplish the same purpose, and all arriving at the same general result. It is not, however, until the end of a period of time that the boilers have been in use that the superiority of any type can be determined in regard to efficiency, and also adaptability for being maintained in good condition at the least possible expense.

In the design and construction of all steam boilers, the principal thought of the engineer should be that of absolute safety. Assuming then that the best possible engineering skill is embodied in their design, and the best materials used in their construction, the first stage in obtaining that end has been accomplished. However, to keep these boilers in a safe condition during their years of future service, requires *constant care* and *frequent inspections* on the part of the operators. It may be truly said that nothing within the province of steam engineering is so subjected to a natural and unavoidable deterioration as the steam boiler, because that source of power is necessarily made up of many units, such as plates, riveted joints, braces, stays, tubes, screwed fittings and a multiplicity of joints, etc., all of which are of such character as to be affected by varying temperatures, causing incessant expansions and contractions, crystalization and deterioration, which tend to make a boiler a constant menace of danger, and no precaution as to its care and safety should be considered excessive or dispensable.



ACCUMULATION OF SCALE AND SEDIMENT SHOWING NECESSITY OF FREQUENT AND THOROUGH INTERNAL INSPECTION.

With this thought in view, and knowing the laws to be few and very lax throughout the country in regard to boiler inspection, the writer has applied to the official authorities of every State in the Union, requesting from them information as to the legal requirements governing boiler inspections in their respective jurisdictions. Out of 46 requests, by letter, replies have been received from 39 States—of these, replies received from 23 States were to the effect that they had no

State laws or any legal requirements governing the inspection of boilers—5 States have laws, and 11 have inadequate provisions embodied in their factory inspection laws. But not a single State has what should be recognized as legal requirements calling for a systematic and obligatory inspection under such rules and regulations as would prove satisfactory to anyone familiar with the necessities regarding the safety of life and property from boiler accidents.

That more and better State laws have not been enacted for the purpose in question has not been the fault of this association, as several efforts were made early in its history to accomplish that end. As far back as 1890, at our third convention, held in New York, Mr. Dundon, a member from California, made a report in favor of a uniform inspection law for the United States and Territories, and recommended a consultation with the United States Attorney-General as to the constitutionality of such a law, and if found feasible, to urge Congress to pass suitable laws for uniform inspections of stationary or land boilers. Following that, in 1894, a bill was drafted at St. Louis, at the instance of Col. Meier and other members, and introduced in the Missouri State Legislature of 1895 by Mr. Kyler, who successfully pushed it through two readings, but on account of conflicting interests with the City of St. Louis and the parsimony and ignorance of the importance of the measure on the part of some country members, the champions of the bill unfortunately failed to get it through a third reading. Also about the same time a draft of the same bill was taken by Mr. Lappan to the Pennsylvania Legislature, through Mr. Kearns, but, after a hard fight by its champions, it also failed for about the same reasons as those ascribed to its defeat in the Legislature of Missouri.

In consideration of the foregoing facts in regard to former obstacles and failures, there appears now, under the inter-State commerce clause, to be no valid reason why we should not have a national uniform inspection law applicable to stationary boilers, similar in its workings to that governing the marine service, under the new Department of Commerce and Labor. That such a law could have been passed by the United States Government heretofore, without conflicting with the old States rights principles, is doubtful, therefore has been the difficulty in having upon the statutes in the past a national uniform inspection law, sufficiently complete in a mechanical sense to standardize the construction and inspection of stationary or land boilers similar to those of the marine service.

Notwithstanding that up to the present time there has been no rigorous and systematic national boiler inspection, yet there has been a partially compelling influence through the A. B. M. Association at least, as far as its membership goes, requiring in the construction of boilers the use of the most acceptable material. If this fact could be established beyond a doubt, it would deter the layman purchaser from accepting a boiler from an unscrupulous builder because of his lower price, and there would not be an incentive for the boiler manufacturer to employ an inferior article in labor and material.

It has been truly said, "that it is not only useless, but criminal, to pass a law which goes beyond the average conscience of a community previous to educating the community to its necessity." In other words, the thought is simply offered that there should be such compulsory national laws embodying formulas and uniform specifications that would compel a safe boiler to be made and thereafter maintained in that condition.

Boiler manufacturers have, in a measure, their reputations to make and preserve, and they should be most vitally concerned in furnishing good, safe boilers, and no doubt the more advanced and better equipped establishments have this object in view, and work to that end; yet there may be a number of other manufacturers throughout the country who, for lack of modern facilities and talent, are still building boilers by the old "rule of thumb" method, and who need correcting—or, to use a more fitting word, educating—in the art.

It is true that many of our large cities have what may be termed "municipal ordinances" looking in a way to the inspection of boilers. Some of these, however, are more or less valueless, by reason of their adoption long ago of rules which, if they ever met the conditions at the time, are obsolete now, and not deemed measures of security by engineers and steam users generally. Thus in order to obtain inspection and some assurance as to safety, the boiler insurance companies are resorted to as a means of protection.

The most positive exception to the inefficiency of local inspection laws is the system adopted by the City of Philadelphia, and which is the only city having a complete and adequate inspection service. I do not mean to say by this that some other cities do not have statutes enough, but they may be in some enforced in a negative manner. For instance, we know of one prominent city having such laws which, if thoroughly administered, would probably prove all that could be desired, but the force of inspectors is inadequate. There are over 6,000 boilers within its jurisdiction, but only one chief inspector and one assistant provided to do the work; while the city of Philadelphia, in comparison, containing but one-fourth more boilers, maintains an adequate force of official inspectors in its Bureau of Steam Engineering, the service procedure of which is as follows: During the course of construction of all boilers at the shops and immediately upon their installation within the city limits, and before being put in service, they are thoroughly inspected internally; also the dimensions of the boilers are noted in the most careful detail; the character of bracing, size and thickness of plates and rivets; tensile strength of all materials, etc., being learned from actual tests and recorded for future reference.

From this data the structural strength of the boiler is ascertained, the rules for which closely follow those of the English Board of Trade, which are generally accepted as containing the best structural formulas. The percentage of strength of the seams, as compared with that of the plate, being determined from their construction, a safe working pressure, with due consideration to diameter of shell, thickness and tensile strength of plate, a factor of safety, commensurate with the strength of the materials, is obtained, and, providing the workmanship is acceptable, the safety valve is set at the safe working pressure, determined by the prescribed rules. The boiler is then filled with water and a hydrostatic pressure one-third greater than the allowable working pressure is applied. Upon the test pressure not developing leaks or other indications of weakness, the operator of the boiler is granted a certificate by the Bureau of Inspection that the boiler is good for one year's service, at the expiration of which time another inspection is made by the same authority; the procedure of the foregoing inspection being followed.

Thus the Philadelphia Bureau of Inspection obtains the following particulars as to data of all boilers in service within its jurisdiction:

1. A determination of the structural strength of boiler.

2. A determination of the character of workmanship.

3. A determination of the "Hidden Defects," or those that can not well be discovered by the hammer and eye test.

4. A complete and continued knowledge of the structural conditions of the boiler.

All of which are recorded in the Department of Public Safety, for reference, as long as the boiler is in use.

In this connection I would state that the department (or bureau) is self-supporting by an annual charge for its service of $3.00 per boiler, and an additional charge of 20 cents per square foot of grate surface therein contained; the expense being borne by the steam user.

The value and effectiveness of the service may be appreciated from the fact that, while there are practically 8,000 boilers in the city, there has not been a boiler explosion of any consequence for 20 years. I emphasize this statement in order that it may be impressive as to the importance of inspection laws.

In some other localities, where the authorities have deemed it advisable to legislate restrictions for the safety of boilers, the "Government or Treasury Department Rules" have been adopted. These rules, however, which were devised solely to fulfill conditions met with in the construction and service of marine boilers, could not be applied in full to stationary boilers, for the reason that until recently the physical conditions of every element or unit entering into the construction of boilers for the marine service were not taken into consideration. While these rules have lately been revised, in order to cover their original defects, it seems that all municipalities which had adopted the same have not as yet followed suit by revising their old rules, and are therefore still working under an obsolete and defective system.

To be more definite, in the way of illustration, New York City, which includes Brooklyn, rates the safe working pressure of boilers without taking into consideration the strength of the longitudinal seams, further than to say: "If boilers are double riveted, 20 percent additional pressure may be allowed," regardless of the percentage of the strength of the rivets in relation to that of the plate. Again, the same law permits the inspector to accept, without question, the tensile strength as stamped on the plates for rating the strength of the boiler. The higher the tensile strength the greater the pressure allowed, regardless of the fact that the tensile strength could be so high as to make the material totally unfit for boiler purposes and yet permit the inspector to issue certificates allowing extremely high pressures; and this, too, for single riveted joints, thus showing the absurdity of the law, which, as it stands, authorizes the issuing of such certificates.

Dwelling further on the matter, I quote from the New York City laws, as follows:

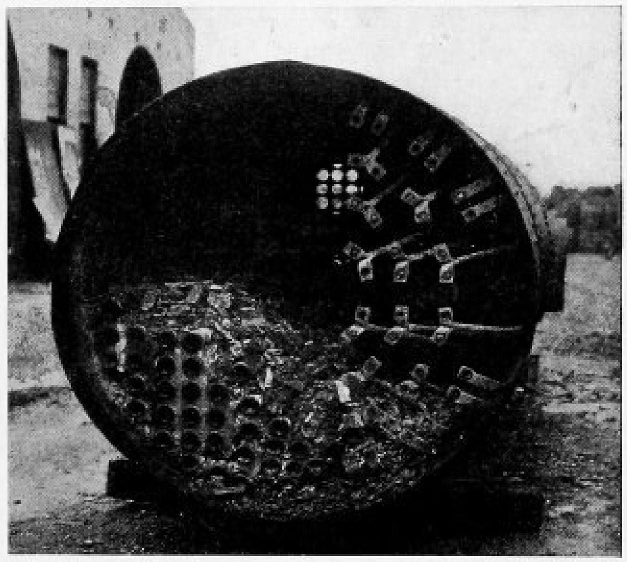
"The strength and security of each boiler shall be tested by atmospheric and hydrostatic pressures, and the strength and security of each boiler, or boilers, so tested shall have such attachments, apparatus and appliances as may be necessary for the limitation of pressure." Now, as to the hydrostatic test, the law in this particular makes it obligatory, but a hammer test only need be made at the option of the inspector. Admitting that the water pressure will show up leaking tubes and defective calking, or even a serious fracture, it serves the purpose in that respect, but does not prove that a boiler having been subjected to 150 pounds hydrostatic pressure alone as a test is absolutely safe under a working pressure of steam. If so, what becomes of our factor of safety which would be used if the proper formulas were followed?

The Legislature of the State of Massachusetts in 1907 passed an Act governing the inspection of all stationary boilers in service within the jurisdiction of that commonwealth, the rules closely following those of the United States Marine Service, and the specifications for boiler steel being similar to those of the A. B. M. Association, with the exception of the chemical properties of phosphorus and sulphur, the percentage of which runs too high in all grades of steel plate, and which should be lowered to agree with the specifications of this association. Notwithstanding, however, that the rules may be somewhat drastic and need revising from time to time to suit rising conditions, the passing of the law by the State was a laudable act, and places it in line as supporting a movement consistent with the usual integrity of the people of that commonwealth. It is hoped that in the near future similar legislation will extend to other States not having such laws, until all the States and Territories become subject to one national law for the uniform inspection of boilers.

The most conclusive argument in favor of a good, uniform inspection law, properly enforced, may be summed up in a paragraph, by quoting from the well-known journal of the Hartford Boiler Inspection & Insurance Company, which is as follows:

"From 1879 to 1907, inclusive, incomplete statistics show that there have been in the United States during that time 8,512 boiler explosions, an average of 304 per year, the number of people killed thereby amounting to 8,433, an average of 301 per year."

"The statistics for the year of 1907 show the number of boiler explosions during that year to be 471; the number of people killed 300; injured 420, or a total of 720 people killed and injured during one year from boiler explosions."



CONDITION OF BOILER DUE TO LACK OF PROPER INSPECTION.

This represents forty more explosions in 1907 than in the year preceding, 1906.

These calamities from boiler explosions alone, coupled with the loss of life and consequent distress following, are appalling, to say nothing of the loss of valuable property. These losses of life and property are in a large measure inexcusable and should not be permitted to continue.

Contrasting the losses of life in this country during 1907, due to boiler accidents, with those in Germany, we find that the boiler explosions in Germany (from report published by the German Imperial Statistical Office) amounted to only 15 during the year, with the loss of 5 lives and 3 injured. Truly, those statistics speak well for the skill and intelligence of German boilermakers, compulsory boiler inspection laws and operating engineers.

That widespread good could come from these remarks is not at all assured, but that we, as a technical organization, should bear these thoughts in view and work indefatigably towards the betterment of present conditions, is within our power. That such a high state of efficiency, however, in uniform inspection as that of Germany could have been established under our States rights form of government, for stationary boilers, has heretofore been impracticable, but under the functions of the new Department of Commerce and

Labor the difficulty of creating a national uniform boiler inspection law, similar in its workings to that of the marine service, it is hoped, has been eliminated.

Therefore it behooves the American Boiler Manufacturers' Association, as a technical society, especially organized in part for the purpose of protecting life and property from the fatalities of boiler explosions, not only to promote the production of a better and safer article than was manufactured twenty years ago, but to also urge the necessity of a uniform national law for the further protection of life and property. No greater opportunity has presented itself within the period of the life of this association to immortalize its existence than to devise the means, on this its Twentieth Anniversary, to secure the necessary legislation toward having placed upon our statutes a national law for the uniform inspection of all stationary boilers or steam generators in active operation within the jurisdiction of the United States.

Flanging Boiler Plates.—II.

BY FRANK B. KLEINHANS.

Hand Flanging.

In flanging plates by hand, much laborious work is necessary. In some instances hand flanging must be resorted to. Small shops are not equipped with the machinery for power flanging and therefore there are cases where hand flanging becomes necessary. In this article it is intended to indicate the method of flanging by hand the various sheets which cannot be shaped by machinery. As a rule, in flanging by hand, the better types of heating furnaces are not always available, so that we have to contend with the problem of flanging sheets which are poorly heated; that is, sheets that are only partly heated, and therefore can be flanged only a small section at a time. Another source of annoyance is the clamping of the sheet. At the best it is a hot job to clamp a heated sheet. Then, too, in many cases the clamps are not always conveniently arranged to be put up and taken off quickly.

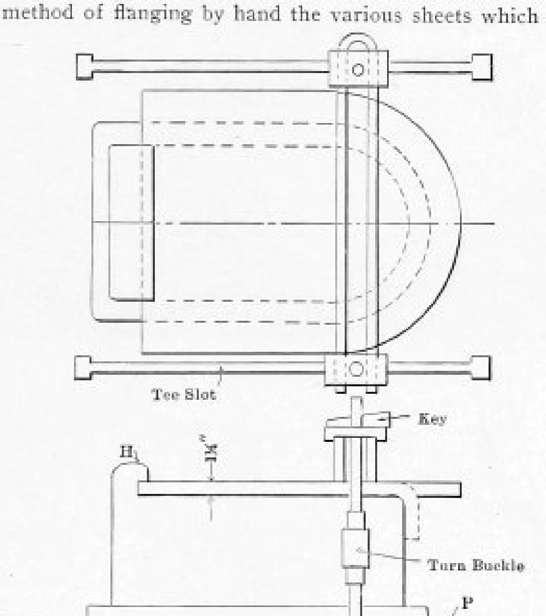


FIG. 12.

In Fig. 12 is shown a flanged sheet which is used for a heavy galvanizing tank. The ends of the flange are turned out and secured to the sides by a row of rivets. Although the tank must withstand the pressure of the metal which it contains, which does not amount to more than 10 or 15 pounds, yet flanged ends are made from $1\frac{1}{2}$-inch plates in order to withstand the constant oxidizing flame which is necessary to keep the metal in a molten condition. It will be noted that the sheet is irregular in shape, and unless the shop is rigged up with a universal flanging machine, it is purely a matter of hammering it out by hand. The shaped die used is made of cast iron. It has three spots on the bottom, so that it will rest evenly on the layingout plate *P* without having to be planed on the bottom. A hooked part *H* extends up and reaches out over the plate as shown. This keeps the plate secure and gives free access for hammering down the flange.

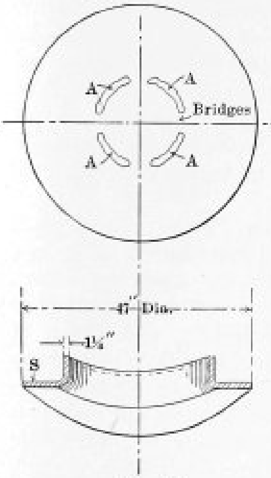


FIG. 13.

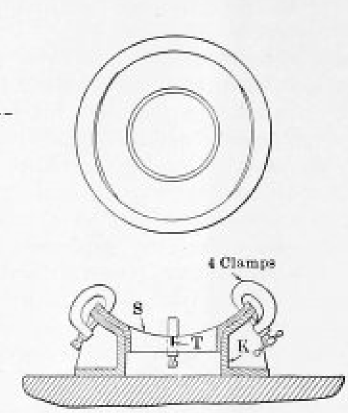


FIG. 14.

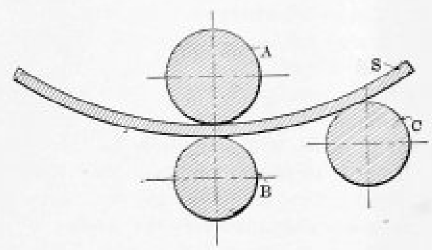


FIG. 15.

The next sheet to be shown is a dome flange, see Fig. 13. This sheet is, of course, in most cases, flanged by machinery, and later on in this series of articles the method of flanging it by hydraulic machinery will be described. For the present this sheet is to be flanged by hand, and the method is as follows:

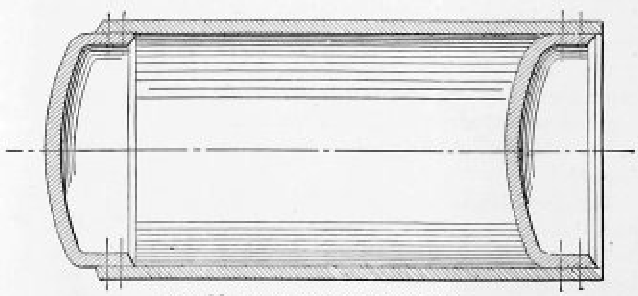


FIG. 16.—HIGH-PRESSURE AIR TANK.

First, the sheet is cut out circular in shape and chipped off on the outside for calking, or preferably the plate is mounted on a boring mill, and the outer surface *S*, Fig. 13, is turned and beveled off for calking. The hole for the inner flange is not cut out, but the metal is punched away as shown at *A*, leaving a sufficient number of bridges to hold the sheet together when the sheet is being bent cold.

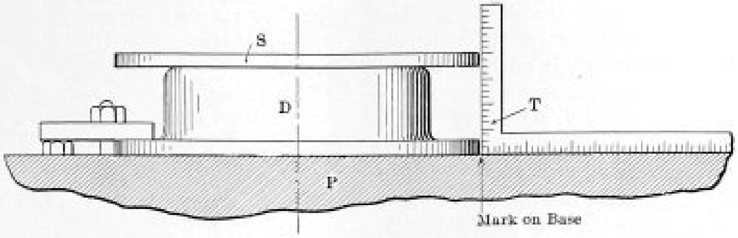


FIG. 17.—CENTERING THE HEAD.

Second, the sheet is now passed through the rolls *A*, *B* and *C*, Fig. 15, and run back and forth until it gradually assumes the curvature of the boiler. It is tested frequently during the rolling with a gage, which is bent to the radius of the sheet which the dome flange is to fit. After the sheet is bent to the desired radius, it is taken out of the rolls and the bridges are punched out and the center removed. The inner edge of the sheet is now chipped smooth and the sheet is ready to be heated for flanging at the inner edge in order to receive the circular body of the dome.

Third, a former *K*, Fig. 14, is now made of cast iron (say) 1¼ inches thick. It need not be made excessively strong, as there is no pounding to be done on the outer edge. Where the hammering does occur, however, the casting has a curved surface, which is very strong. Mark off the center of the die *K* with a good heavy line, or drill a hole and drop in a pin. The dome flange is also marked off for the center line and center punched good and deep. This marking is done on both sides. The dome flange sheet is now ready to be heated. Build a good wide fire, using large pieces of coke. Build up three brick piers to the proper height and place the sheet on them; now lay larger pieces of coal over the hole and check the flame, throwing it back over the sheet in order to escape. When the sheet attains a good uniform red heat, it is picked up with the bars and placed over the dies and clamped down as shown in Fig. 14. The men now pound down the flange uniformly as far as possible. On account of the awkward shape of the piece, it is difficult on small flanges to get the inner flange hammered back properly. After the sheet is removed, any place that is flat can be hammered back from the other side, where one has better access to the sheet.

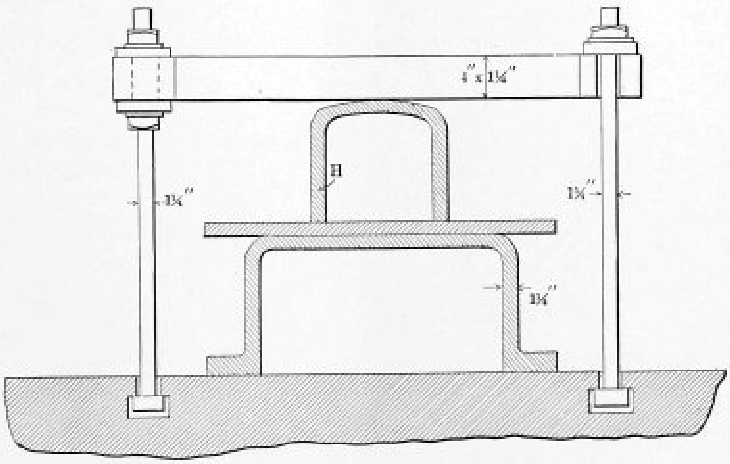


FIG. 18.—CLAMPING THE HEAD ON THE FORMER.

Another sheet which sometimes has to be flanged by hand is that which is used for the heads of high-pressure air tanks. These are round sheets, but they are also dished out to a radius equal to the diameter of the tank. This sheet and its relation to the tank are shown in Fig. 16. A die is used for setting the outside flange. This is driven home first and then the sheet is dished afterwards.

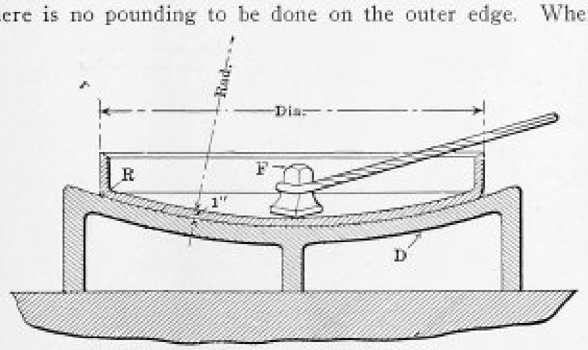


FIG. 19.—DISHING THE HEAD.

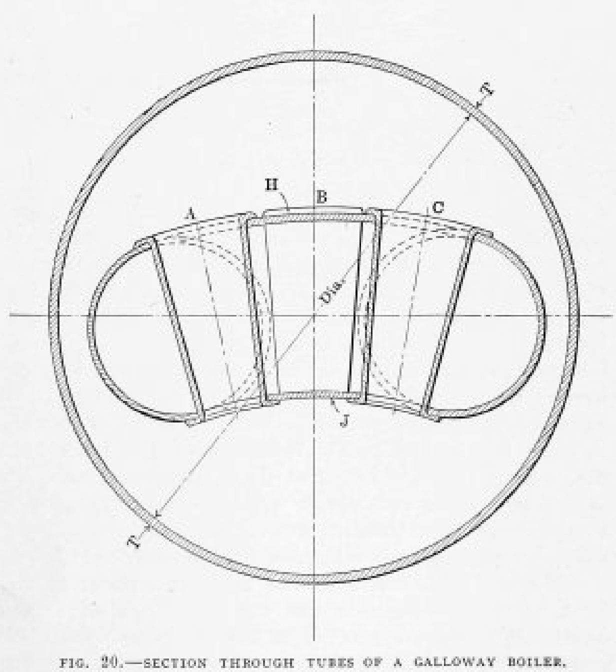
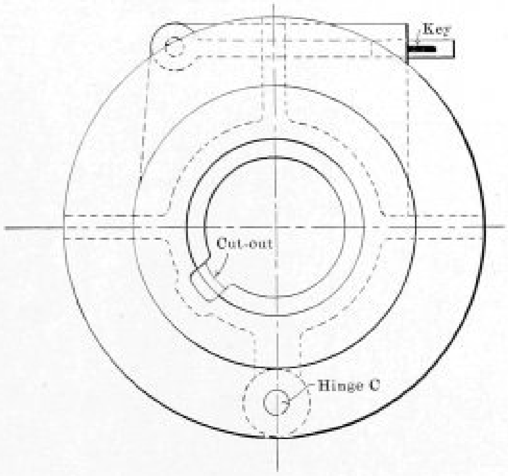


FIG. 20.—SECTION THROUGH TUBES OF A GALLOWAY BOILER.

The die, *D*, Fig. 17, is secured to the layout plate. The sheet *S*, after being properly heated, is centered on the die with a square *E*. The holder, *H*, Fig. 18, is now put on the sheet, the clamp bar is swung into place and the bolts are tightened up. This holds the head firmly in place. The outer edge is now gradually mauled down, reheating being necessary to drive the flange home securely all around, as the sheet is very thick. The head is now reheated in the center, nearly up to the point where the flange begins; it is then placed in the hollow die *D*, Fig. 19, while one man holds the flatter *F*. Several men then pound the sheet down with heavy sledges, the flatter being applied around the outer edge first, and gradually worked toward the center. If the sheet is 1 inch thick and the diameter 36 inches, the radius of the dish would be 37 inches to the outside of the head.



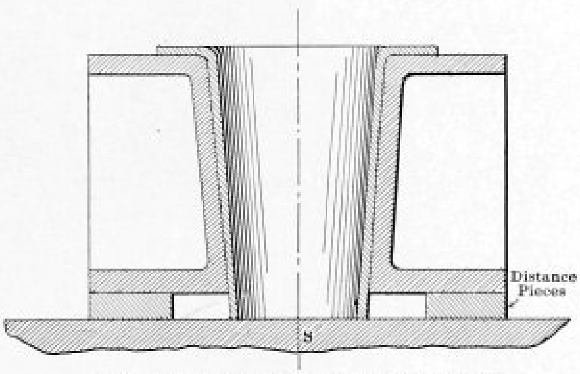


FIG. 21.—DIES FOR FLANGING GALLOWAY TUBES.

In Fig. 20 are shown the conical tubes *A*, *B*, *C* of a Galloway boiler. The tubes are riveted along the vertical seam, and the top and bottom edges are flanged over to receive rivets which fasten them to the top and bottom sheets *H* and *J* of the fire chamber. The vertical seam is riveted except at the ends where the flanges occur. The conical sheet is dropped into a die, Fig. 21, and the bottom rests against a stop *S*, which insures the length being correct. The upper edge is now flanged down against the die. The exact shape of this sheet is to be marked out by the layingout gang and not by the flange gang, except in so far as the extra amount may be required in flanging in order to make a thoroughly good job. However, we might mention that the sheet will expand on the top outer edges as it is being pounded down, but at the edges it will not stretch, and therefore an extra amount of metal must be allowed in order that the two edges will overlap sufficiently to make a good, tight job, the bottom sheet being scarfed off and the top edge being beveled off for calking. The dies are now opened by means of the hinges, as shown in Fig. 21, the cut-out at *C* being for rivet heads and the seams.

The bottom flange is not formed until the tube is placed in

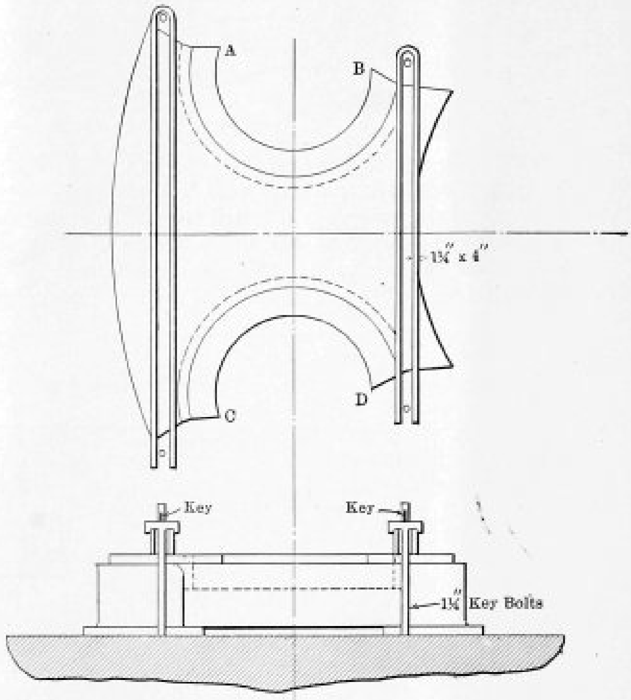


FIG. 22.

position in the boiler. The rivets in the top and bottom flange are now driven and the seams calked tight.

The connecting sheet from the firebox to the fire chamber is shown in Fig. 22. It is first clamped down on the forming dies, and the flange for one tube is worked down in place. An extra amount of metal must be allowed at the corners *A*, *B*, *C* and *D*, as the metal will not stretch here, while on the

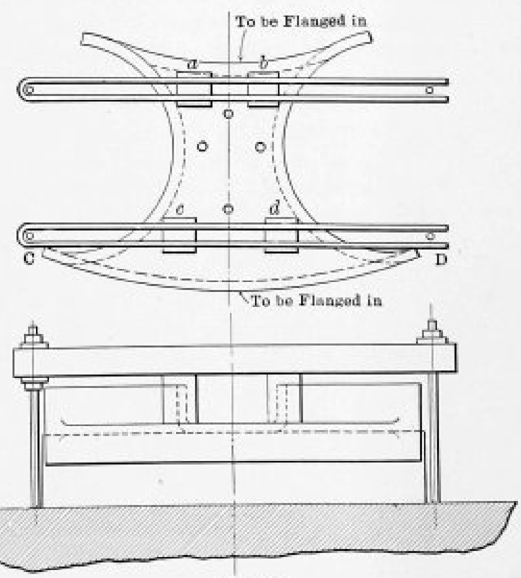


FIG. 23.

contrary it will be drawn away from the corner by the metal further in along the flange. The other side is now heated and worked in against the dies, the sheet is then removed, reheated and placed up side down on another forming die, shown in Fig 23. The clamps are blocked up at *a*, *b*, *c* and *d*, so as to clear the flange, and the clamps are then tightened up. The top or bottom flange is now mauled down. The top corner of the flange *c d* is held by a man with one or more bars to keep it from bending over and following after the sheet as the lower course is being driven home. These ends will be more or less out of shape when the sheet is taken from the die and will have to be shaped up with the flatter afterwards.

These illustrations have been given with the idea of covering, as well as possible in the space allotted, the subject of hand flanging. It is not to be presumed that these sheets will always be made this way in the works, but these pieces must be flanged at times by hand for various reasons, and therefore it is important to be able to handle the job by hand when necessity demands it.

(*To be continued.*)

Layout of an Uptake.

Rectangular Uptake Intersecting a Cylindrical Conveyor Diagonally.

INTRODUCTION.

Occasionally instances arise in the setting of boilers and smoke-boxes that conditions will not permit the up-take to set parallel to the smoke-box conveyor. To overcome this obstacle the layout herein shown can be readily applied. It will be seen that the up-take sets diagonally to the smoke-box conveyor.

Three views are used in developing this particular case to obtain the data for the layout. Ordinarily in shop practice, however, the information could be gained from two views only; but since the up-take sets other than central upon the smoke conveyor, it is deemed advisable to show clearly how all the data are obtained.

CONSTRUCTION.

First draw up a section of the conveyor, then of the up-take, according to their respective measurements, showing the relative position of the smoke-box to the conveyor. (See Fig. 1, plan view.) Examination of Fig. 1 (plan view) will disclose the fact that since the up-take is not equally divided on each side of the center line *XX*, the respective ends will require individual development. If the up-take were central all the information could be obtained from only one view. Only one end view is absolutely necessary, but for the sake of clearness two have been drawn, and the data pertaining to each end worked up independently.

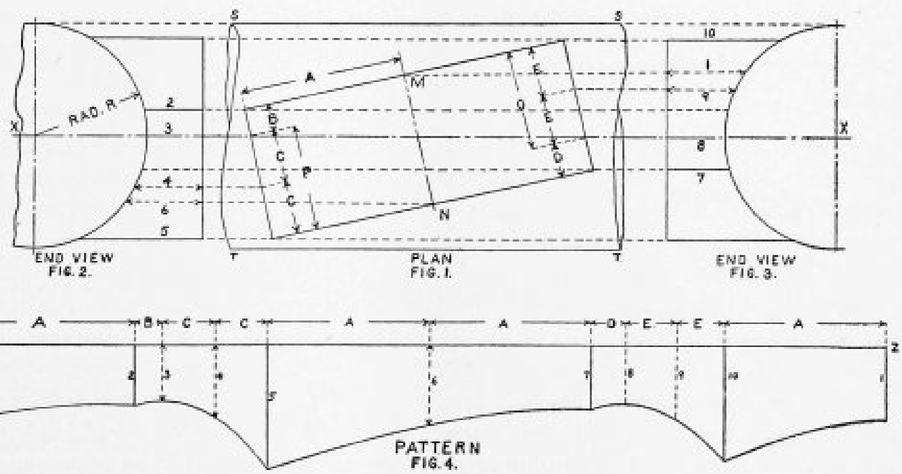
In drawing the plan view, Fig. 1, it will be necessary to show a portion of the smoke-box as well as the correct position of the up-take.

First draw the two parallel lines *SS* and *TT* any convenient length in excess of the diagonal length of the up-take, making the distance between the two lines equal to the diameter of the conveyor. Draw the center line *XX*, and then locate the up-take on each side of the center line in the exact position relative to the smoke conveyor; thus locating the distances *O*, *D* and *P*, *B*. Divide the distances *O* and *P* into any number of equal spaces; in this instance each line is divided into two equal spaces *C*, *C* and *E*, *E*.

Since the up-take is located on only one-half of the smoke conveyor, it will be seen that it is necessary to draw only one-half of the conveyor, as shown in the end view, Figs. 2 and 3, where the radius *R* is equal to one-half the diameter of the smoke conveyor. Then extend lines from the extreme points of the up-take to the semi-circles, thus locating the lines 2, 5, 7 and 10.

On the center line *XX* lay off the distances 3 and 8, which are equal to the true height of the up-take. After the height is ascertained connect lines 2 and 5, 10 and 7, by drawing vertical lines at right angles to the line *XX*. Then bisect with the trammels the length of the up-take, making *A* equal to one-half the length. Extend lines over from the center points *M* and *N* to the semi-circles, thus giving the heights 6 and 1.

Bisect the distances *O* and *P*, and project horizontal lines over to the end views, as shown, locating the lines 4 and 9.



DEVELOPMENT.

To lay out the pattern, Fig. 4, draw the horizontal "stretch-out" line *Y*, *Z* of sufficient length to make the up-take in one sheet. Then lay off the distances *A*, *B*, *C*, *C*, *A*, *A*, *D*, *E*, *E* and *A* to correspond to the spaces lettered the same way in Fig. 1, and at these various points draw vertical lines as shown. Lay off on these vertical lines the respective distances from 1 to 10, inclusive, as measured from Figs. 2 and 3.

Care must be exercised in laying off the correct distances on the proper vertical lines in Fig. 4. This is easily traced up by following the lines of intersection in the plan view, Fig. 1. Having located the points, draw in the irregular curved line, add the necessary allowance for laps, etc., and the pattern is complete.

In Europe bending rolls are largely superseded by vertical plate bending machines. These machines are virtually curved dies, which are forced together by hydraulic power bending a small section of the plate at a time to the desired curvature. They have the advantage not possessed by most bending rolls, that the plate can be curved clear to the edge.

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.

The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Uniform Inspection Laws.

Two possible ways of securing uniformity in the construction and inspection of steam boilers have been suggested. The first is the enactment by Congress of a national law, giving the government control over all boilers operated on land as well as those operated on the navigable waters of the United States. The second is the passage of similar laws by the individual States. There is no question but what the first method would be the best, but until recently it has been considered out of the question, since the principle of States rights was thought to make such a law unconstitutional. Under the new Department of Commerce and Labor, however, in accordance with the inter-State commerce laws, there is a possibility that such a law might be passed. It is idle to speculate on this point, however, until some opinion is obtained from the Attorney-General of the United States regarding the constitutionality of such a law.

The second method is entirely feasible, but needs some strong power to put it in practice. It is well within the scope of State legislation to enact laws governing the construction and inspection of all boilers installed in the State, and at present five States have such laws. It is another thing, however, to secure the passage of such laws in all States, and, even if this could be accomplished in every State in the Union, it would still be a difficult problem to secure uniformity in these laws. The only interests which at present are seeking to bring about this much-to-be-desired legislation are the boiler manufacturers. The general public is not sufficiently well informed regarding the vital necessity of the existence of such laws to take an active interest in bringing them to pass. Steam users in general are in much the same position, and engineers, except those who devote most of their time to boiler work, and there are comparatively few that do, have too little interest to undertake any movement of this kind. The boiler manufacturers are, then, the ones upon whom we must depend to take the lead in this matter. At present they are going about this work in a way which is most likely to secure the best results. That is, they are obtaining a revision of the United States marine laws governing the construction and inspection of boilers, with a view to making these rules an adequate standard which will naturally be adopted wherever new laws governing steam boilers are enacted. Their efforts deserve the hearty support of everyone who is in a position to give them any assistance, and we sincerely hope that they will ultimately result in adequate government inspection of all boilers in the United States, whether it is through the medium of a national law or through State laws.

Flanging.

There are some things about boiler making which it is possible to learn from text-books, but there are more things which can be learned only by experience in the shop. One learns in the shop, however, not only by seeing the work done, but by being told the whys and wherefores by the man who is doing it. Such information can, with the aid of suitable illustrations, be just as well imparted by means of books or magazines, if the space can be devoted to it. Many subjects are too broad for detailed treatment in text-books, but it is possible by means of the trade paper to bring a vast amount of such information before the men who really need it. Articles describing shop operations have always had a valuable place in our columns, and for this reason we are particularly glad to offer to our readers a splendid series of articles on the subject of flanging boiler plates. These articles, the first of which was published last month, deal in a practical way with a subject which depends largely upon practical experience for its application. Good flangers are rare. Men who can operate a single machine can usually be found, but one who understands thoroughly how to attack any problem in flanging which may come up, either by hand or by machine, and who can estimate the effect of the heat treatment on the material and carry out the work without any loss of material, is a hard man to find. We heartily commend these articles to all of those who are interested in this important subject.

Railway-Contract-Marine.

In order to define more exactly the scope of this magazine, we have added the terms railway-contract-marine to our name as it appears on the front cover. Since December, 1904, when the present management assumed control, The Boiler Maker has endeavored to present monthly to its readers the latest developments in shop practice and in the design and construction of all types of steam boilers. Our field is not limited by any one branch of the industry, but includes all.

COMMUNICATIONS.

Round House Flue Work.

Editor The Boiler Maker:

After reading the article entitled "Roundhouse Flue Work" in the June number of your journal, I desire to take a few exceptions to the views of the writer of the article. He claims that it is because the tubes are from 16 to 20 feet long that there is so much trouble with tubes leaking. From the experience which I have had with both long and short tubes it is impossible for me to agree with him, as I get more mileage out of tubes 20 feet long than I do from tubes 16 feet long, and more mileage from tubes 16 feet long than I do from those that are only 11 or 12 feet long. I think the main trouble with flues in the roundhouse is with the boiler maker who usually gives his work a lick and promises to do better next time.

The writer of the article referred to, on a wager, made an engine do five trips without knocking the fire. If this can be done once, it can be done again if the same care is taken.

I would like to ask the writer what becomes of the factor of safety where the beads wore off the tubes and some of them pulled an eighth inch through the sheet?

As to the prosser tool, it is the best tool that can be used in the roundhouse, either on old or new work, but I do not think that the prosser tool should be used exclusively in roundhouse work. It is like all tools, it has its time and place. Experience has taught me that the beading tool properly handled should be used on hot work, but when the engine is being washed or is cooled down, then the prosser should be used. With this method and an honest workman there will be no trouble with roundhouse flue work. J. R. Cushing.

Bending Rolls.

Editor The Boiler Maker:

In your June issue is a description of a special plate-bending roll, manufactured by the Hilles & Jones Company, Wilmington, Del., in which the upper roll is directly over one of the lower ones, the advantage of this arrangement being that the plates can be bent clear to the extreme edge. There is another advantage for this type of roll which was not mentioned; viz., there is no difficulty in feeding the plates into the rolls, as the two leading rolls bite the plate and force it through without the use of sand or any other aid. About twenty years ago the writer built a set of rolls of this kind and they are still in use at the Silver Brothers' Iron Works Company, Salt Lake City, Utah. Many years ago this type of rolls was very widely used in London. In the "Engineer and Machinists Assistant," published in Glasgow, in 1847, on plate 54 is a drawing of such a machine by Richard Napier, of Glasgow, the rolls being about 12 inches diameter and 10 feet long. It has often been a question with the writer why this arrangement has not been used more frequently, as the advantages are so apparent, and, so far as I am aware, there are no corresponding disadvantages. William J. Silver.

A Handy Countersink for Patch Bolts or Rivets.

Editor The Boiler Maker:

In countersinking holes for patch bolts, I use a 1½-inch twist drill, ground with a considerable taper, the operator's judgment being used, of course, in grinding the drill. I find that the cutting edge of this tool lasts longer than with the old style flat countersink. This tool can be used equally well for patch bolts or rivets. I have countersunk as many as ninety holes for rivets at high speed without using either water or oil. Harry Jewell, Albany, N. Y.

Patch for High-Pressure Boiler.

Editor The Boiler Maker:

In the June issue of The Boiler Maker I noticed an article by Mr. G. W. Smith, on "How to Apply a Patch on a High-Pressure Boiler for Good Results." I do not think Mr. Smith's methods would hold good on a Scotch boiler. My opinion is that he should put the patch on the inside, using a thin strip of copper extending 3/16 inch back of the calking edge; also using copper washers punched with a 13/16-inch washer punch and screwed into the countersink with the bolts. Mr. Smith speaks of using a 21/32-inch drill, which is customary with a standard tap, but which I find by experience to be too large for a 12-thread patch-bolt tap. As I consider this subject one of vast importance, especially on high-pressure work, I would like the opinion of other readers on this subject. George W. Brock.

How to Find the Length of the Arc of a Circle.

Editor The Boiler Maker:

Referring to the question asked by "J. B. R." in the July issue of The Boiler Maker, regarding the method of finding the length of the arc of a circle, the diameter of the circle and the number of degrees in the arc being known, I beg to suggest the following rule which I find convenient and also easy to remember. It is simply a case of proportion; that is, the length of the arc is to the circumference of the circle as the number of degrees in the arc is to 360. Conversely, if it is necessary to find the number of degrees in the arc, knowing the length of the arc and the diameter or circumference of the circle, the number of degrees in the arc is to 360 as the length of the arc is to the circumference of the circle.

G. H. H.

PERSONAL.

John Cook, of Springfield, Ill., has resigned his position with the Springfield Boiler & Manufacturing Company and intends to start in business for himself.

E. S. Fitzsimmons, formerly master mechanic of the Galion (Ohio) shops of the Erie Railroad, has been transferred to master mechanic of the Hornell (New York) shops of the same road.

Carl Lunkenheimer, first vice-president of the Lunkenheimer Company, Cincinnati, O., died at Pasadena, Cal., Sunday, July 19. Due to ill health he had spent most of the time in California for the last few years.

William C. Reilly, formerly of the Franklin Boiler Works, is now layer-out at the New York Central shops, West Albany, N. Y.

J. B. Holloway resigned his position as City Boiler Inspector, Los Angeles, Cal., on March 17, 1908, after over five years of service. He is now connected with the Mason Smokeless Combustion Company as constructing engineer, with headquarters at 426 South Spring street, Los Angeles, Cal.

Theodore T. Mersereau, formerly United States local inspector of boilers of steam vessels, port of New York, has been appointed sales agent for the marine department of the Casey-Hedges Company, manufacturers of boilers at Chattanooga, Tenn. This company has decided to extend its business and compete for the marine work on the North Atlantic Coast. Their branch office is at 100 William street, New York City.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q. 1.—What is the life of a ¾ or ⅞-inch rivet die for a pneumatic riveter?

Q. 2.—What is the best kind of steel to use for the rivet die of a pneumatic riveter?

Q. 3.—Do these rivet dies often break off, leaving the shank in the hammer barrel? Why? Pneumatic.

A. 1.—The life of a rivet die depends very largely upon the kind of work on which it is used and the care which the workman uses. In some cases a set of dies has lasted for 50,000 rivets, while in other cases the dies have been broken in driving a thousand rivets. In ordinary boiler work it would, perhaps, be safe to say that a set of dies could be used for about six weeks before going back to the tool room for redressing. Continued use of a die on hot rivets tends to draw the temper of the die and shorten its life.

A. 2.—A high grade of steel should be used for rivet sets, since good steel runs very evenly and takes the temper more uniformly. Sanderson's "Special" is highly recommended by both manufacturers and consumers.

A. 3.—Rivet dies frequently break off at the point where the shank joins the die. This frequently happens when "rolling" or calking a cold rivet, or driving drift pins or staybolts. In these operations the hammer is not held straight on the work and an undue strain is caused at the edge of the rivet set. A great deal of this breakage can be overcome by the proper tempering of the dies, and by using care in keeping the riveting hammer snugly up against the work. In one case it was found that the shanks were made too neat a fit, and that the dies had been overhardened. After these defects were remedied there was very little trouble in the breakage of dies. A wide fillet at the point where the shank joins the die materially strengthens the die and tends to resist breakage at this point.

Q.—In the article, "Lay-out and Construction of a Large Water Tank," published in your July issue, it does not state how to obtain the curve for the ends of the sections which form the hemispherical bottom. These are shown as straight lines in the development of the sections, shown in Figs. 10 and 11, page 221. How do you obtain the proper curve for the ends of these sections, and also should the sections be dished or simply rolled and put together like the sections of an elbow? M. F. W.

A.—The ends of the sections, sketches of which are shown in Figs. 10 and 11, page 221 of our July issue, should be curved as follows: The wide end of Fig. 10 should be cut off straight, as shown in the sketch, as this joins the cylindrical part of the tank. The narrow end of this plate should be curved to a radius of approximately 30 feet 11 7/16 inches, as shown by the tangent line, Fig. 5, page 219. Similarly the wide end of Fig. 11 should be curved to the same radius, and the narrow end to a radius approximately 5 feet 4⅞ inches, as shown by the tangent line, Fig. 5. These sections were dished to form a true spherical surface. This is shown quite plainly in the photograph, Fig. 1.

Q. 1.—How did the custom originate of paying boiler makers for ten hours' work when they are working out in the field, and the actual time put in is only nine hours?

Q. 2.—What is the average pay of boiler makers in the East? In your April issue, an article describing an estimate of the cost of a small Scotch boiler states that a layer out receives 25 cents an hour; a boiler maker 24 cents an hour and helpers 15 cents. In California boilermakers receive from $4 to $4.50 for eight hours' work, and the helpers $2.50.

Q. 3.—Which is the proper way to repair a boiler that has bagged on the bottom on account of the accumulation of mud or scale in one spot? Should the pocket be cut out and a patch put on, or should it be heated and driven back into place?

Q. 4.—What is the smallest size patch that should be double riveted? Cal.

A. 1.—The custom of paying boiler makers for ten hours' work when they are working in the field and the actual time put in is only nine hours, is due to the fact that the extra hour is allowed to enable the workman to go to the shop and get his tools and get to the place where the work is to be done. When a man is employed in a certain shop he naturally locates his home in some place which will be convenient to his work, and if his employer sends him to some distant place to do the work, he must allow him a certain amount of time to go and come.

A. 2.—The scale of wages for boiler makers differs slightly in different parts of the country. The rates which you quoted from our April issue prevail in a certain part of Canada. In the eastern part of the United States boiler makers average from thirty to forty cents an hour and helpers from 12½ to 25 cents. In the South the average rate is somewhat less, boiler makers receiving from $2.50 to $3.50 per day, and helpers from $1.50 to $2.00 per day. In the Middle West, boiler makers receive from 25 to 35 cents an hour and helpers from $1.75 to $2.50 a day. In the West boiler makers average from 40 to 45 cents an hour, and helpers from $2 to $2.50 a day.

A 3.—The proper way to repair a boiler that has bagged on the bottom will depend largely upon circumstances. A patch is a poor thing to have over the fire, as it forms a double thickness of metal which is sure to fire crack and is hard to keep tight. Furthermore, a patch over the fire should only be single riveted, and since a single riveted joint cannot be made much more than 50 percent as strong as the solid plate, this means a weak place in the boiler, and a probable reduction in the pressure carried. If the plate is in good condition, and the bag not too serious, it would probably be safe to heat the plate and drive it back into place, but if it is necessary to cut out the pocket, the safest way to repair the damage is to put in a whole new half sheet.

A. 4.—The smallest size of patch that should be double riveted would depend entirely upon the size of the boiler and pressure carried. Although a single riveted seam does not have much over 50 percent of the strength of the solid plate, yet if placed diagonally, with regard to the axis of the boiler, its efficiency can be increased somewhat, so that it is capable of taking the place of a double riveted seam.

Q.—How do you calculate the proper size of steam dome for a boiler? What should be its ratio to the boiler and what bearing does the steam cylinder of the engine have on the design of the dome? D. E. B.

A.—The principal function of a steam dome is to provide dry steam. It also serves to increase slightly the steam space in the boiler, although in high-pressure boilers the steam dome is seldom made large enough to add very much to the steam space. There are no fixed rules regarding the ratio of the size of the steam dome to the size of the boiler; the designer should be guided entirely by practical considerations. Regarding the relation of the cylinder of the engine to the dome the entire steam space in the boiler is usually made such that it will contain a sufficient volume of steam to supply the engine for twenty seconds; thus, the ratio of the volume of the steam space of cylindrical boilers to that of the high-pressure cylinder of multiple expansion engines varies from 50 to 1 to 140 to 1. The ratio of the steam space of a simple locomotive engine to the volume of the two cylinders is about 6½ to 1. With engines which make but a few revolutions per minute and take steam for only a portion of the stroke, a much larger steam space is required, and those boilers which are used to supply steam for walking beam engines for paddle wheel steamers are usually provided with a large steam dome to increase the steam space. The steam dome is being very generally abolished on cylindrical boilers, as it has been found to add comparatively little to the steam space and to make little difference in the dryness of the steam obtained from the boiler, while on the other hand it is expensive to build, and unless properly stayed, makes a weak place in the shell of the boiler. Adding a steam dome to a boiler sometimes gives sufficient additional steam space, so that an additional row of tubes can be put in the boiler, thus increasing the heating surface.

Q.—Kindly publish the layout of the irregular section shown in Fig. 1, which has a round base and connects to a smaller round opening at the top at right angles to the base. W. E. D.

A.—As this is an irregular form it must be developed by triangulation. Divide both the base and the circular open-

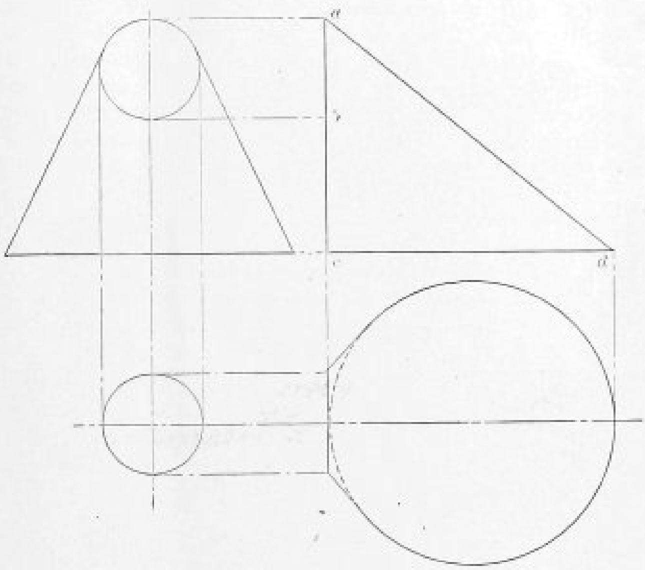


FIG. 1.

ing at the top into any number of equal parts. In the drawing, Fig. 2, one-half the base and one-half the upper opening have been divided each into six equal parts. Points in the base are numbered 2, 4, 6, 8, 10 and 12; those in the upper opening, 1, 3, 5, 7, 9, 11 and 13. It will be necessary

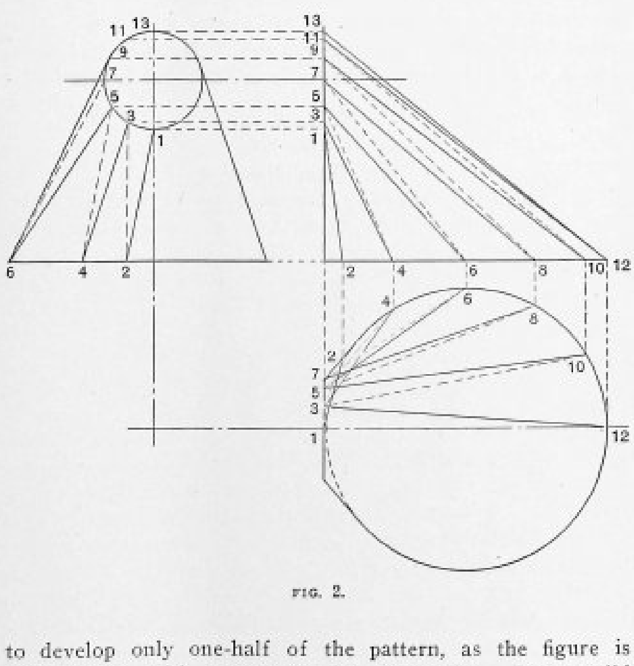


FIG. 2.

to develop only one-half of the pattern, as the figure is symmetrical, with respect to the center line. Draw solid lines connecting points 1 and 2, 3 and 4, 5 and 6, and so on, up to 13 and 12. Also draw the dotted lines connecting points 2 and 3, 4 and 5, 6 and 7, and up to 10 and 11. These lines divide the half surface into twelve triangles, and, if the true lengths of these lines can be obtained, the pattern can be developed by placing these triangles in their proper relation one to the other.

The true lengths of these lines may be found by constructing right angle triangles, the bases of which are equal to the length of the lines, as shown in the plan view, and the altitudes of which are equal to the vertical distance between the upper and lower ends of each line. The hypotenuse, or third side, of these triangles will then be the true lengths of the lines. These are shown in Fig. 3, all the solid lines being laid out on one side of the center line, and all the dotted lines on the opposite side. Each line is numbered to cor-

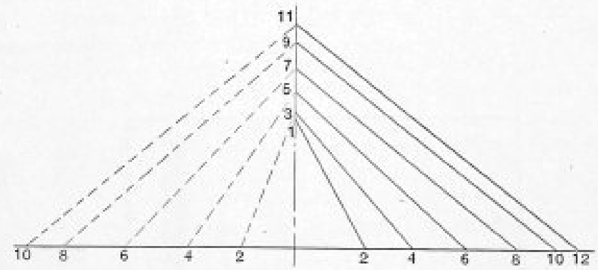


FIG. 3.

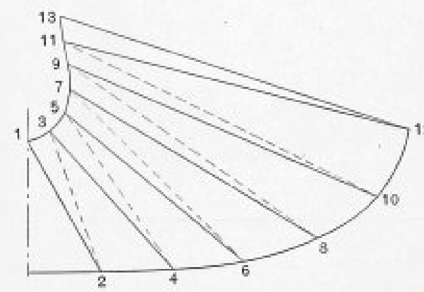


FIG. 4.

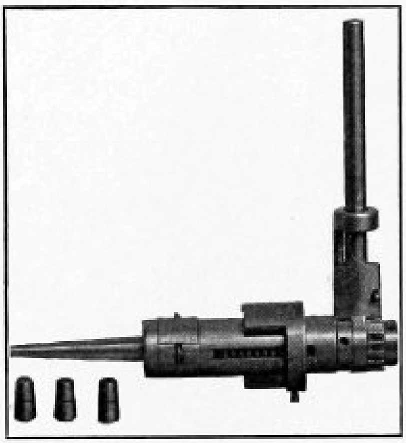
respond with the notation in Fig. 2. Thus to find the true length of the solid line 1-2, lay out on the center line, Fig. 3, the vertical height of point 1 above the point 2 in Fig. 2; then from the center line lay out along the base line the length of the line 1-2, as shown in the plan view, Fig. 2. Thus the points 1 and 2, Fig. 2, are located, and the line joining them is the true length of the line 1-2, as it should be laid out in the pattern.

Having determined the true lengths of the lines which are to form the triangles, draw the center line for the pattern; then selecting any point, as the point 1, lay off along this line the width of the pattern at its narrowest point. Set a pair of dividers to the length of the equal spaces 1-2, 2-4, etc., in the base, and then from the lower end of the center line strike an arc through the point 2. From the point 1, with the trams set to the true length of the line 1-2, strike a second arc intersecting the one just drawn, locating point 2. Set another pair of dividers to the length of the equal spaces 1-3, 3-5, etc., in the upper opening of the piece, and with 1, Fig. 4, as a center strike an arc through the point 3. Set the trams to the true length of the dotted line 2-3 and with 2, Fig. 4, as a center strike another arc intersecting the one previously drawn, locating point 3. Continue in a similar manner to locate points 4, 5, 6, 7, etc., until the points 12 and 13 have been located. Draw a straight line through points 12 and 13 and a smooth curve through points 1, 3, 5, 7, 9, 11 and 13, also through points 2, 4, 6, 7, etc., completing the outline of the half pattern.

ENGINEERING SPECIALTIES.

A Combined Flue Expander and Cutter.

The Ditch Adjustable Sieve Company, Mansfield, Ohio, have placed on the market a combined roller flue expander and cutter, which operates on the screw-feed principle. The advantages claimed for this type of expander are: First, the use of a hammer is done away with, and in its place a lever wrench or ratchet is used by means of which the operator can gage accurately the pressure on the rolls; second, there is no backing away of the expander from the work, as is the case when a hammer must be used. The screw feed holds the expander up to its work when a hard spot or uneven place in the flue is met; third, the rolls are made so as to accurately fit the taper of the mandril in order to give them a perfect bearing throughout their full length. This insures that the flues are rolled with the same pressure for the entire thickness of the flue sheet, whereas rolls which are made cheaply and do not conform to the taper of the mandril, exert an uneven pressure on different parts of the flue and damage the work.



The expander can be changed in two minutes' time to a flue cutter by removing the rolls and placing in their stead the shoes containing the rolling cutters. It is claimed that the cutters leave a smooth tube, which is the best possible shape for beading. By interchanging the rolls and cutters, the same tool can be used to cut out an old set of flues and replace and expand the new set.

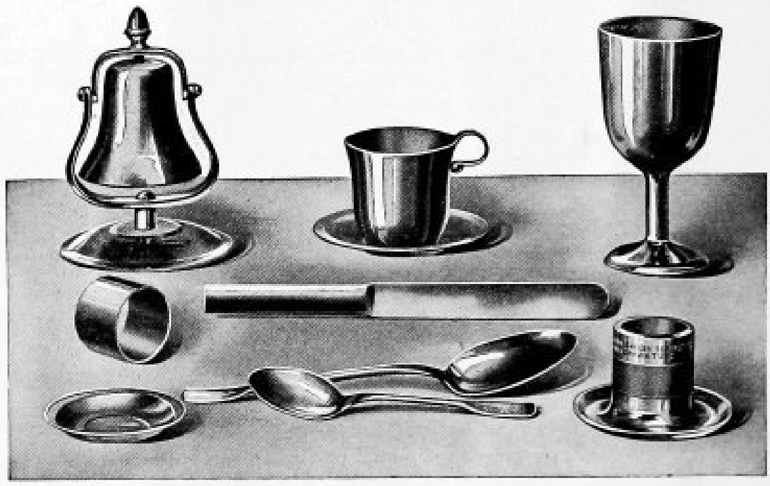
The Cleveland Staybolt Chuck.

It frequently happens when running in a stay-bolt that the bolt will stick and stop and must be backed out part way in order to get a fresh start. The Cleveland reversible stay-

bolt chuck, manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, is designed to be operated in either direction at will. The necessary grip on the bolt is obtained by a loose roller which changes its fulcrum automatically and wedges the bolt fast against the two stationary dogs. When the motor to which the chuck is attached is reversed, the roller of the chuck releases its hold and moves to the opposite side, when it again grips the bolt fast. This chuck is designed to drive stay-bolts from ¾ to 1⅛ inches in diameter. It can be applied directly to standard bolts without the necessity of squaring the ends.

Shelby Seamless Steel Tubing.

That the product known as the Shelby seamless steel tubing has been used for hundreds of different purposes is a well-known fact, but perhaps nothing illustrates its adaptability to different uses so strikingly as the articles shown in the illustration. These articles, which form a complete lunch set, are selected from the individual pieces which formed a portion of a large set manufactured for use at a banquet given sometime ago to the officers of the National Tube Company, Pittsburg, Pa., manufacturers of the Shelby seamless steel tube. The dishes were formed, not cast, and it will be observed that this material may be hammered flat, as shown in the knife blade and spoon handle; curved in or out, as in the plate and spoon bowl; left in its original form, as in the napkin ring; expanded at one end to several times its original diameter, as in the goblet; or formed into a bell. The manufacturers claim that material which is capable of being shaped in this manner is eminently suitable for use in boiler tubes.



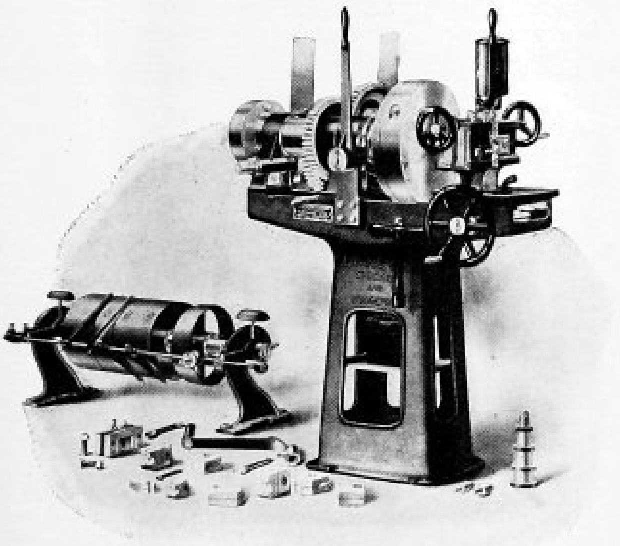
A New Pipe Machine.

This machine is placed on the market by the Crane Company, Chicago, to meet the demand for a low-priced machine, operated by hand or power, for high-class service. All parts have been designed to withstand any strains that such a pipe cutting and threading machine may be subjected to. Simplicity of operation, adjustment and arrangement has been carried out to the minutest detail.

This tool possesses many features which increase output and facilitate ease of operation. The gripping, threading, cutting-off and adjustment have been so arranged that no unnecessary operations are required. The frame is one casting, having bed and stand in one piece, eliminating the use of light legs, and giving greatest rigidity with minimum weight and floor space.

The die head is bolted to a movable carriage, with ample travel. Upon the die head are the dies, pipe guides and cutting-off tool. The dies are of the improved adjustable type, made collapsible. They are carried in suitable frames, sliding in guides, and moved by a screw operated by a hand wheel. They are set to gage by a simple locking device, which allows any number of pieces of pipe of the same size to be threaded without any further adjustment. These dies have four cutting edges, and will give good service on either steel or wrought iron pipe. Dies are made interchangeable, and one die of a set may be replaced if broken, thus reducing the repair bill to the minimum.

When cutting off, the pipe is guided by two steel guides, hardened on the face. These guides are operated by a right and left screw and hand wheel. The cutting-off tool is operated by a lever and rack. This makes a rapid, simple and

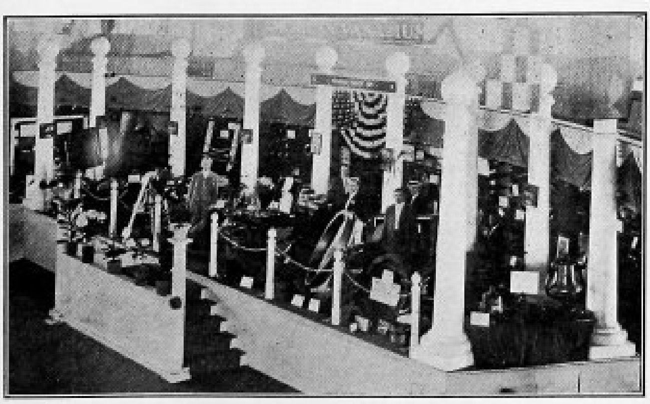


positive device and extremely powerful. The gripping chuck is of the quick gripping type, rapid in action and very powerful. Pipe may be released and gripped by the throwing of a lever without stopping the machine. The chuck is adjustable to the different sizes of pipe within range of the machine, without moving or altering the jaws. The jaws are of tool steel carried in steel holders, and are removable for grinding or replacing.

The capacity is from $\frac{1}{8}$-inch to 2-inch pipe. The dimensions of the countershaft pulley, running at 200 revolutions per minute are $9\frac{3}{4}$ inches diameter by $3\frac{1}{2}$ inches face. The floor space required is 44 by 23 inches; the weight, 700 pounds.

Vanadium Steel.

Much interest was manifested in a recent exhibit by the Vanadium Sales Company, of Pittsburg, Pa., of vanadium



products. The variety of the specimens was considerable, including open hearth and crucible steels treated with vanadium, vanadium cast iron, vanadium steel castings and vanadium copper and bronze, of considerable hardness, strength and ductility.

In drop forgings, vanadium steel flows quite readily in the die, its heat treatment being very simple. No more trouble is experienced in machining it than is met with in the ordinary steel with an equal proportion of carbon. The forgings take a high finish. Its peculiar quality to resist deterioration, arising from vibration, strain and fatigue, is exemplified in the service of a large number of vanadium steel springs now in use. A locomotive tender truck spring exhibited had been straightened 10,000 times under much greater force than would have been necessary to flatten any other type of spring, and this without any permanent set. Among the other exhibits was a wheel taken from under a locomotive tender weighing 140,000 pounds, this wheel having run 26,875 miles and showing a wear of but 1/16 inch in diameter. The average life of the regular steel wheel is only a little more than 10,000 miles.

A six-throw crank shaft for an automobile was another item. Still another exhibit was part of a torpedo, recently tested with gratifying results. Where great strength, toughness and power of resisting shock are desired, this material seems to have a large future before it.

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.

884,728. CLEANER FOR STEAM BOILERS. Isaac C. Gray, of Logansport, Ind., assignor to Automatic Boiler Cleaner Company, of Logansport.

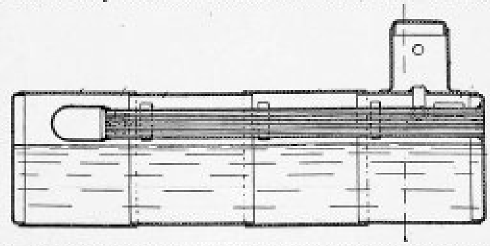
Claim. In a steam boiler, the combination of a casting secured to an outlet in the bottom of the boiler, said casting having two branches; a short and a long blow-off pipe lying near the bottom of the boiler secured to said branches; a pipe connected to said casting leading to a surface skimmer, a hollow rotary valve located in said casting and provided with a single port adapted to communicate successively with each of said pipes, and steam jet pipe entering said valve and secured thereto, and means exterior of the boiler for turning said pipe and valve. Three claims.

885,295. WATERTUBE BOILER. Andrew L. Riker, of Bridgeport, Conn., assignor, by mesne assignments, to the White Company, of Cleveland, Ohio.

Claim. A boiler comprising a central column and a plurality of concentrically arranged groups of coils encircling said column and entering the same at varying heights at both their ends, said coils being of unequal inclination, and the tubes thereof increasing in diameter inversely as the inclination. Two claims.

886,087. STEAM SUPERHEATER. Joel Nikolaus Stern, of Falun, Sweden, assignor of one-half to Hugo Theodor Tillquest, of Stockholm, Sweden.

Claim. In a device, the combination with a steam chamber, of a plurality of gas pipes extending thereinto and secured in one wall only of the steam chamber, and a connecting



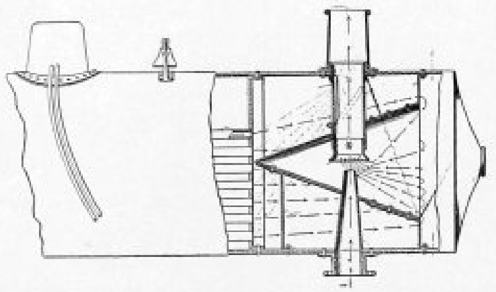
chamber arranged within said steam chamber and adapted to retain the ends of the gas pipes within said steam chamber and provide for communication between said pipes. Eight claims.

887,409. BURNING OIL FOR GENERATING HEAT. Thomas C. Mason, of Los Angeles, Cal., assignor, by direct and mesne assignments, to Mason Smokeless Combustion Company, Inc.

Claim. The apparatus for burning oil for generating heat, consisting of a combustion chamber, an arch therein, an externally fired steam boiler, a burner whereinto oil and steam are led in regulated quantity, situated within and near the inner end of said combustion chamber. flues one at each side of the apparatus, openings for admitting air into said flues, doors on said openings for regulating the quantity of air admitted, an arch above the arch of the combustion chamber, inclosing spaces forming parts of the flues, these flues leading into a transverse flue, and a discharge flue, from which the heated air is discharged both beneath and above the burner, an upwardly inclined arch at the rear part of the apparatus and at a higher level than the combustion chamber, for directing the heat and products of combustion up among the upper ends of the inclined tubes of the externally fired steam boiler. One claim.

887,278. LOCOMOTIVE DRAFT REGULATOR. Walter A. Skinner, of Moberly, and Thomas F. Cain, of Montgomery City, Mo.

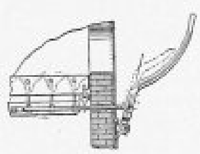
Claim. In a locomotive boiler furnace, the combination with the smoke-box, exhaust nozzle, smokestack and draft pipe extending downwardly from the smokestack into the



smoke-box, of a funnel supported within the smoke-box with its open end foremost, the upper end of the exhaust nozzle and the lower end of the draft pipe projecting into said funnel. Seven claims.

887,523. FURNACE-GRATE ROCKING AND LOCKING DEVICE. Fred. W. Ridlon, of Springfield, Mass., assignor to Perfection Grate Company, of Springfield, a corporation of Massachusetts.

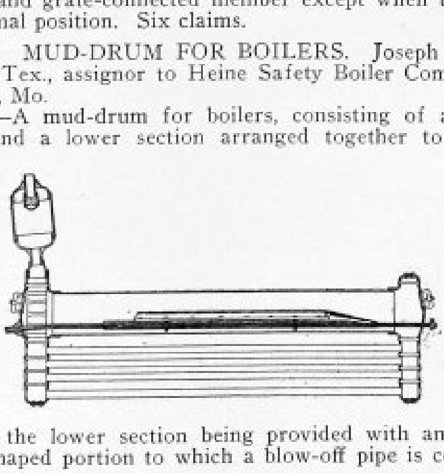
Claim. In a rocking bar furnace grate operating mechanism, the combination of a grate-connected member, a stationary fulcrum member, a lever handle provided intermediate its



ends with a longitudinal slot cut therethrough adapted thereby to couple wifh said grate-connected member and to fulcrum removably on said fulcrum member, and means for locking said lever handle against disconnection from said fulcrum member and grate-connected member except when the latter is in normal position. Six claims.

888,127. MUD-DRUM FOR BOILERS. Joseph Stroope, of Lyra, Tex., assignor to Heine Safety Boiler Company, of St. Louis, Mo.

Claim.—A mud-drum for boilers, consisting of an upper section and a lower section arranged together to form a



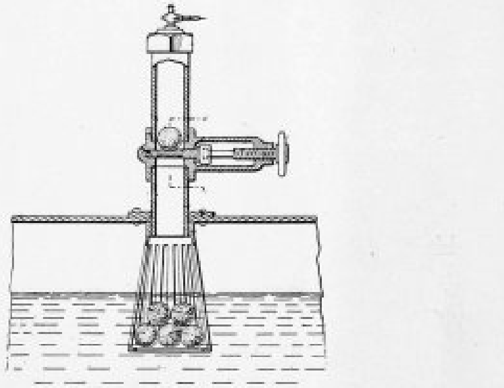
cylinder, the lower section being provided with an integral conical-shaped portion to which a blow-off pipe is connected. Four claims.

888,178. WATER GAGE. Charles A. Kenney, of Trenton, N. J.

Claim.—A water gage comprising a gage glass having a boss at each end and shoulders surrounding said bosses, a case having openings through which the glass may be seen, said case being internally screw-threaded at its ends, nipples engaging the threads in the case and having sockets into which the bosses extend, and packing washers between the inner ends of the nipples and the shoulders of the glass. Two claims.

888,469. DEVICE FOR SUPPLYING SCALE-REMOVAL COMPOUNDS TO BOILERS. George W. Case, of Lestershire, and Harry C. Haggerty, of Binghamton, N. Y.

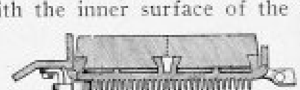
Claim.—In means for supplying compounds to boilers, a receptacle positioned in a boiler, a chamber secured to said



receptacle and projecting from said boiler, a receptacle designed to be brought into communication with said chamber and said receptacle, and means for separating said chamber and said receptacle. Seven claims.

890,067. FURNACE DOOR. Charles G. Y. King, of Chicago, Ill.

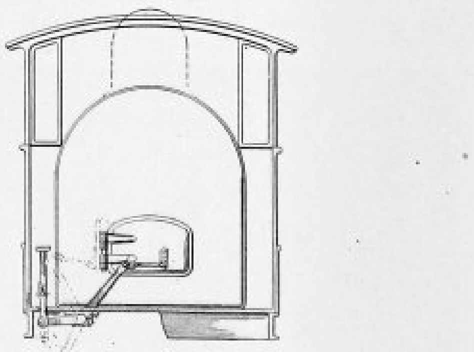
Claim.—In a furnace door, a door casting, a lining for the inner surface of said casting, means for offsetting said lining from contact with the inner surface of the casting to form



a space therebetween, and means arranged on the outer surface of the door casting for dissipating the heat of said casting. Four claims.

890,325. FURNACE DOOR OPENER AND CLOSER. Lewis Andrews, of Apopka, Fla.

Claim.—The combination with a furnace door hinged to swing to the left of the furnace in opening, of a horizontally disposed shaft extending parallel with the furnace and located to the left of the furnace door, an arm connected to the end of the shaft next to the furnace and inclined upwardly to-



wards the door, a link loosely connected at one end with said arm and at the other end loosely connected with the door, a spring encircling the horizontally disposed shaft and adapted to be placed under tension in rotating the shaft to open the door and in its recoil to rotate said shaft to close the door, and a foot lever connected with the end of the horizontally disposed shaft farthest removed from the door for swinging the door to the left and placing said spring under tension. One claim.

THE BOILER MAKER

VOL. VIII SEPTEMBER, 1908 No. 9

CORROSION AND INCRUSTATION—A SOURCE OF BOILER EXPLOSIONS.

The necessity for thorough and conscientious inspection of steam boilers at regular intervals by competent men, in order to avoid any tendency toward wasting of the boiler by corrosion or damaging of the plates and tubes by a heavy incrustation of scale, is brought to the attention of boiler makers and engineers frequently and forcibly by the number of places where dangerous conditions are found to exist. Damage to a boiler by corrosion may be begun as soon as the boiler is built, even before it is placed in operation. The action once begun is very likely to be augmented and continued if certain conditions, which we shall describe later, exist after the boiler is placed in operation. Damage due to incrustation or scale formation does not, of course, begin until the boiler is used, but there are few places where feed-water can be obtained which is entirely free from scale-forming substances, and where a suitable installation can be made to remove such impurities from the feed-water before it enters the boiler. Therefore, damage due to both of these causes is sure to occur to a greater or lesser extent in nearly every steam boiler as time goes on.

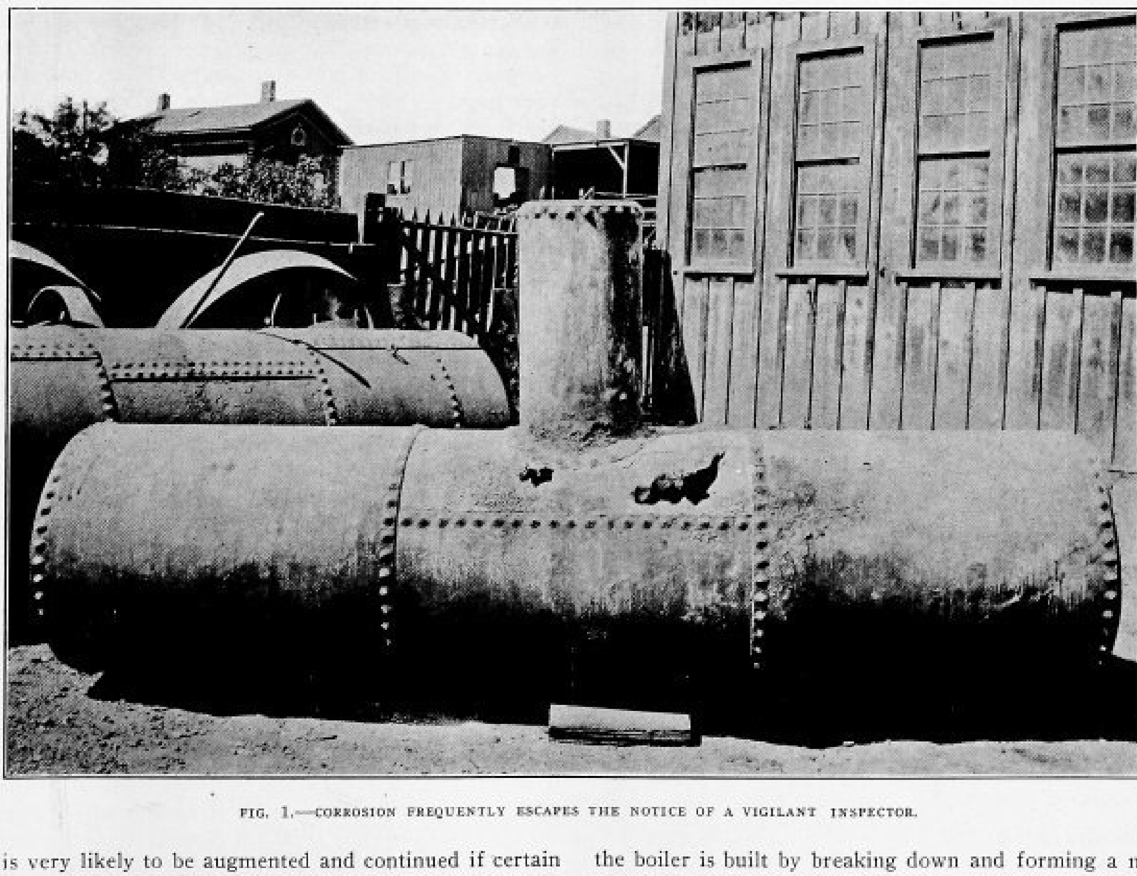


FIG. 1.—CORROSION FREQUENTLY ESCAPES THE NOTICE OF A VIGILANT INSPECTOR.

Corrosion may be due to the presence of oxygen, in which case the iron or steel is simply oxidized, and ordinary red iron rust is formed, frequently in a thin scale, which does not become detached from the plate until it is shaken off by hammering or jarring the boiler. In addition to the ordinary oxidation process, certain acids are frequently found in boilers, sometimes being contained in the feed-water and sometimes finding their way in with the oil which is carried over from the engine cylinders. These acids attack the metal of which the boiler is built by breaking down and forming a new substance called a salt, which is composed partly of the acid and partly of the metal attacked.

Corrosion of the first kind takes place whenever oxygen, moisture, carbon dioxide and iron are present together. There is usually more or less air in the feed-water, and carbon dioxide is frequently liberated from the salts entering with the feed-water. Even if free carbon dioxide is not present the corrosion may go on just the same, being induced by an electrochemical action. Corrosion due to the latter cause usually takes the form of pitting rather than of uniformly distributed rusting, and can be very largely prevented by placing zinc in the boiler as a protective substance. Zinc is electro-positive to iron, and, therefore, the activity of the electrochemical action is diverted from the iron to the zinc, which will be destroyed before the iron is attached perceptibly.

A good example of the destructiveness of corrosive action in a boiler is shown in Fig. 1. For the photograph and description of this boiler we are indebted to Mr. David Wight, San Jose, Cal. The boiler was purchased second-hand about seven years ago by the manager and bottler of a beer agency

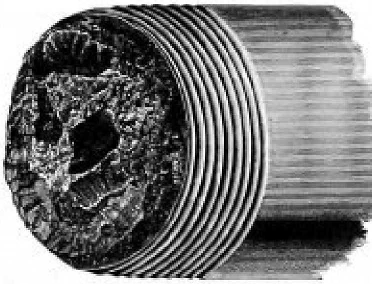


FIG. 2.—A FEED-PIPE CHOKED WITH A STONE-LIKE SCALE.

in San Jose, and was placed in operation at a pressure of 100 pounds per square inch. It is a hand-made, single-riveted lap seam boiler, 30 inches in diameter by 10 feet long. The shell is of ¼-inch iron. From the style of the steam dome, Mr. Wight suggests that it might have been built 25 or 30 years ago, probably in San Francisco.

On the 19th of April, 1906, the day after the famous earthquake in California, Mr. Wight was called upon to make a new smokestack for the boiler, as the other one had been destroyed by the earthquake. After the broken steam pipes were replaced and the machinery put in working order, steam was raised on the boiler. As soon as steam was up it was noticed that steam was coming up through the sand on the top of the boiler near the dome. The boiler was bricked in

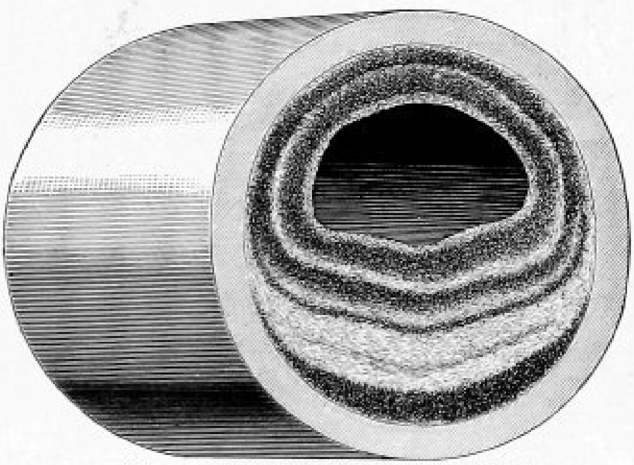


FIG. 3.—A FEED-PIPE CONTAINING A HEAVY DEPOSIT.

and the bricks covered with loose sand. This suggested to Mr. Wight that there might be a hole eaten through the shell, but the manager did not consider the subject seriously, attributing the steam to the fact that it had been raining and thoroughly wet down the boiler setting, so that the heat from the boiler would be likely to cause a slight generation of steam from the dampness of the sand on top of the boiler.

The boiler was regularly inspected and pronounced in good shape and safe for 100 pounds steam pressure. About a month after one of these inspections Mr. Wight was called upon to inspect the boiler, as steam was coming up by the dome in vast quantities. This was two years after the escape of steam at this point was first noticed. This time, however, it was apparent that there was a good-sized leak, and so pressure was reduced on the boiler and the bricks taken down. It was found that there was a good-sized hole in the shell, and the plate was easily smashed in with a hammer, as shown by the photograph. The immediate cause for the increased escape of steam from the leak at that particular time was due to the fact that two men had been covering the steam dome with asbestos, and in walking around on top of the boiler had loosened a patch of rusty scale that covered the hole.

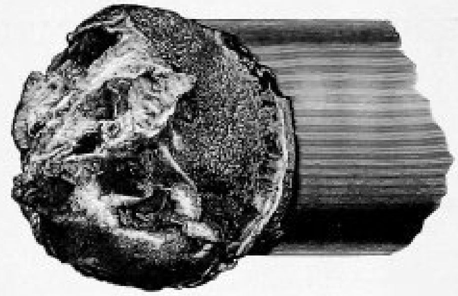


FIG. 4.—A FEED-PIPE NEARLY SEALED UP BY SCALE.

This instance shows what a dangerous condition corrosion may cause in a boiler, especially as the scale formed by the corrosive action served to cover up the extent of the damage and deceive a careful inspector, for one of the best inspectors in the neighborhood had spent about an hour inside the boiler only four weeks before the failure occurred, carefully examining it and hammering the plates, although a cold-water test was not put on the boiler. Very likely if such a test had been made, the defect would have been apparent at once.

Even more serious damage may occur in a boiler due to scale formation than due to corrosion. The principal constituents in ordinary feed-water, such as is used in land or stationary boilers, which tend to form scale are calcium carbonate and calcium sulphate. Ordinary river water contains in the neighborhood of 75 percent calcium carbonate, and only a small percentage, say 4 or 5 percent, of calcium sulphate, while in more brackish water the percentage of the two constituents is more nearly equal, being in the neighborhood of 30 or 40 percent.

Calcium carbonate usually exists in water in the form of calcium bicarbonate, a substance which is soluble in water, while calcium carbonate itself is practically insoluble in water. When the water is heated in the boiler carbonic acid is driven off from the bicarbonate of calcium, leaving calcium carbonate, which is thrown down in a solid condition. This deposit, which is of a powdery nature, unless mixed with other impurities, can be washed and swept out of the boiler after allowing the boiler to cool down and the water to run out.

Calcium sulphate is more soluble in cold water than in hot, and is precipitated at a temperature of about 280 degrees F., which corresponds to a steam pressure of 35 pounds per square inch. It forms a hard scale, which adheres closely to the plates and tubes, especially if there is any binding material, such as clay, sediment or particles of heavy oil, to combine with it. Once this scale is formed the only safe way to remove it is by means of proper chipping and scaling tools wherever it is possible to reach the scale with them. Tannic acid may be used to break up scale, but it also attacks iron. The more common way to counteract the effect of calcium sulphate is to introduce soda-ash into the feed-water, which results in giving a deposit of calcium carbonate which, as has already been said, can be washed or blown out of the boiler and a solution of sodium sulphate which can be blown out from time to time.

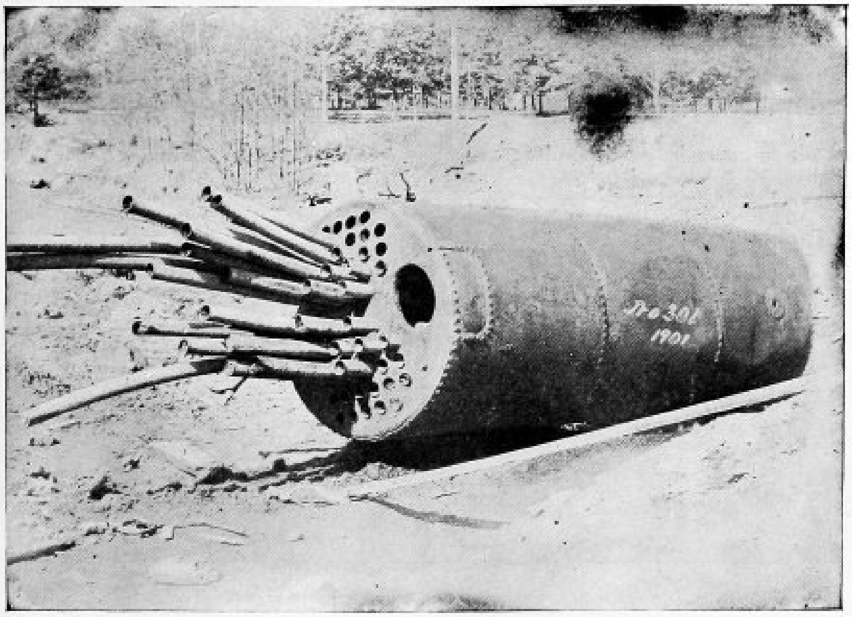


FIG. 5.—FRONT END OF BOILER WHOSE EXPLOSION WAS DUE TO SCALE FORMATION.

By courtesy of the Hartford Steam Boiler Inspection & Insurance Company, we are enabled to illustrate and describe a number of interesting instances showing the harmful effect of scale formation in boilers, feed pipes, etc. Figs. 5 and 6 show two views of a boiler which exploded at the plant of a Texas salt refining company, due to a heavy accumulation of scale around the ends of the tubes. One fatality and three seriously injured besides a total property loss of about $6,000 was the result of this explosion.

When the boiler was examined after the explosion it was found that both heads were bulged to the extent of about 5½ inches, although the shell was intact. The rear ends of the boiler tubes had pulled out of the rear head, and the reaction of the flow of water and steam from the fifty-six tube holes caused the entire boiler to be hurled a distance of 173 feet. All of the tubes with one exception remained in the boiler, though most of them protruded from the front head, as shown in the illustration. One tube was found 273 feet from the original position of the boiler. This tube had at one time leaked near the front head, and it was plugged with scale, so that the steam pressure forced it out through the head as though it were a solid cylinder.

The feed-water for the boiler came from a salt-producing district, and produced a considerable amount of scale, fragments of scale varying in thickness from 3/16 to ⅜ inch were removed from the rear ends of the tubes after the explosion. Scale had formed around the ends of the tubes, which were simply expanded into the head, and in the course of time they became thin, causing a certain amount of trouble with leaky flues.

The probable cause of the explosion was explained as follows: The tube ends became thinned from wear, and the scale that formed around them and against the rear head caused these parts to become hot so that the holding power of the

FIG. 6.—REAR END OF BOILER WHOSE EXPLOSION WAS DUE TO SCALE FORMATION.

tubes was materially reduced. The stress that was thus thrown upon the braces proved too much for them, and they broke under the ordinary working pressure. The heads then bulged outward, drawing the tubes out of their holes, and the rest of the observed results followed as a natural consequence.

Figs. 2, 3 and 4 show three examples of feed-pipes which were almost completely choked up by the formation of a heavy, hard scale. In the case shown in Fig. 2 the deposit consists of carbonate of lime, which was deposited because the feed-water, becoming heated by the steam and water in the boiler, would no longer hold it in solution. Naturally, most of the deposit passed through to the boiler, while some of it kept accumulating in the feed-pipe, with the result shown in the illustration. Practically the same thing happened in the case shown in Fig. 3. The pipe shown in Fig. 4 is filled with a solid, stony scale, which was found to be fully as hard as granite. Not only feed-pipes but also blow-off pipes are particularly liable to be choked up in this way, either by scale or by sediment and require careful attention.

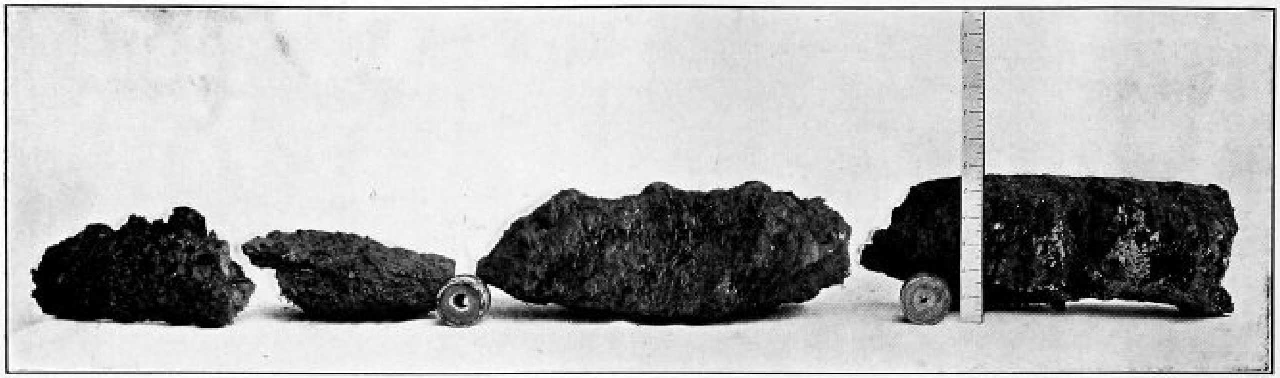


FIG. 7.—PIECES OF SCALE 3 INCHES THICK TAKEN FROM A BOILER PRONOUNCED BY THE MAN IN CHARGE TO BE CLEAN AND IN FIRST CLASS CONDITION.

FIG. 8.—SECTION OF 4-INCH TUBE FROM WATER-TUBE BOILER NEARLY CHOKED WITH SCALE.

The following incident is related by Mr. J. W. Rausch, of the Maryland Casualty Company, showing why it is undesirable to trust too much to subordinates for careful inspection of boilers where there is danger of scale formation:

One of our inspectors visited an unusually large power plant for the purpose of inspecting boilers. Everything about the plant was apparently in the very best condition. At this plant special men are detailed to do nothing but look after the repairs and the cleaning out of the boilers. The chief engineer pointed to one of the boilers, saying, "You may start on that one, but I hardly think it necessary to get inside, as I have just received a report from the man in charge, who reports everything in first-class condition," and on holding a light inside of the manhole the boiler certainly did look to be in excellent condition. However, the inspector, like the man from Missouri, "wanted to see," and it is well that he did. He first got into the manhole above the tubes. The tubes were found fairly clean, but a solid mass of scale was found on the back head between the tubes and the shell. This scale extended down to the lower row of tubes, the water space being solid with scale for a distance of 1 foot from the back head; also both sides were practically the same. In breaking out the scale we succeeded in getting a piece 12 inches long, 3 inches thick and 6 inches wide. An external examination showed that the shell plates at the points where the scale was found were very badly bulged and burnt. The rivets and the edge of the lap of the head seam were nearly gone. In order to put the boiler in safe condition extensive repairs were necessary.

Fig. 7 shows some of the scale which was taken from this boiler, and as may be seen from comparison with the rule shown in the photograph, the amount and thickness of scale was such as to place the boiler in a dangerous condition.

From incomplete statistics of boiler inspectors the total number of defects which are found in steam boilers may be included under, roughly, twenty-three different items. Of these items incrustation and corrosion account for about 25 percent of the total number of defects reported, the number of defects due to deposits of scale and sediment usually averaging about 15 percent of the total, and those due to corrosion about 10 percent of the total. The only other defect which is found with anywhere near the same frequency is dangerous leakage around tubes or cases of defective tubes. The number of cases of this kind probably averages in the neighborhood of 15 percent of the total. Thus it will be seen that corrosion and incrustation are the source of a large amount of trouble with steam boilers, and anything which can be done to eliminate or minimize their effect will tend to make the operation of boilers safer.

Boilers were built as early as 1813 to carry 100 pounds steam pressure. They were 5 feet in diameter and 30 or 40 feet long with an internal fire tube. It took four or five months to build each boiler, and the largest plates obtainable were 3 feet by 1 foot. It was necessary to hammer them into the proper curve, and the rivet holes seldom came opposite each other. A light hammer was held against the rivet heads in riveting in place of the present heavy one, so the rivets used to slip about and the plates were never hammered home so as to make a tight joint.

Size and Capacity of Safety Valves for Use on Locomotive Boilers.*

No uniform practice seems to have prevailed in the past in proportioning safety valves to the work they are to perform. The locomotive builders follow specifications of the railroad companies, and it seems to have been the practice of the railroad companies to base their specifications on what has been done before on similar locomotives. The various railroad companies have fallen into the practice of specifying so many 2½, 3, 3½ or 4-inch valves, which, when reduced to exact language, does not mean anything definite. Obviously, two 3-inch valves having a sustained lift of ⅛ inch have a greater capacity for the discharge of steam than eight 3-inch valves having a sustained lift of 1/32 inch each. The committee does not wish to convey the idea that the two 3-inch valves having a sustained lift of ⅛ inch are better for the boiler than eight 3-inch valves having each a sustained lift of 1/32 inch. It simply wishes to point out the errors that may arise from the practice of specifying so many valves regardless of the sustained lift.

Perhaps the most important part of any investigation should be the determination of the proper amount of evaporation which the safety valves shall be called upon to relieve. We already have information as to the maximum evaporation of locomotives from the tests at St. Louis in 1904, but the committee feels that the safety valves would never be called upon to relieve this amount from the fact that the combustion in the firebox is stimulated by the exhaust, and that this exhaust is caused from the use of the steam in the cylinders, so that, at a time of greatest evaporation, the steam is being used approximately as fast as it is generated. Hence, it remains for the investigators to determine what shall be deemed the proper amount of relief in safety valves. Then, too, the lift of valves of various sizes at the different pressures must necessarily be determined, as also the effect of this lift on the life of the valve seats and the tendency the lift of the valves may have to raise the water in the boiler.

It is no less important that some data be collected on open and muffled valves, and in this connection, considering the tendency of the muffler to retard the flow of steam through the valve, it is of importance that we review the work of Mr. Brownlee on the flow of steam through an orifice, which is contained in a "Report on Safety Valves" in the transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. XVIII, 1874-75, page 13. In this report Mr. Brownlee has compiled some data on the rates of discharge under a constant internal pressure, into various external pressures, upon which D. K. Clark, in his work on the steam engine, bases the following statements: "The flow of steam of a greater pressure into a receiver of a less pressure increases as the difference of pressure is increased, until the external pressure becomes only 58 percent of the absolute pressure in the boiler. The flow of steam is neither increased nor diminished by the fall of the external pressure below 58 percent, or about four-sevenths of the inside pressure, even to the extent of a perfect vacuum. In flowing through a nozzle of the best form, the steam expands to the external pressure, and to the volume due to this pressure, so long as it is not less than 58 percent of the internal pressure. For an external pressure of 58 percent and for lower percentages, the ratio of expansion is 1 to 1.624."

From the foregoing, one is led to believe that the muffler produces no appreciable retarding effect on the safety valve. The committee feels that this should be verified in present practice.

*From a report presented at the annual convention of Master Mechanics, June, 1908.

As stated, it is essential that the amount of evaporation that the safety valves should relieve be determined. This can best be determined by applying two safety valves of known diameters and lift, which, according to the empirical formula, are known to be a little small. A third valve, of a larger diameter and set to pop at a somewhat higher pressure than the smaller valves, should be applied as a means of protection. If at any time during the test the two small valves go into action and the boiler pressure rises above the popping point, it would be reasonable to assume that the valves were of insufficient capacity. Another trial with valves of a larger diameter would no doubt prove of sufficient capacity. By changes in this manner it would be possible to apply two valves of sufficient capacity, and the diameter, lift, and form of valve being known, it would be a simple matter to obtain the amount of evaporation that the valves were called upon to relieve on the particular type of locomotive in question. It is important in this connection that the observation of pressures be very accurate, and the committee would suggest that a pressure-recording gage be attached to the boiler to serve as a check on the observer. Perhaps the most reliable method of determining the lift of the valves would be to attach a rod to the top of the valve stem. This rod could be connected to a lift-recording gage and also to a lift-recording mechanism, operated by a small motor, which, while recording the lift on the card, would also record the time element. This mechanism would give an accurate check on the gage observations. It is understood, of course, that the lift measurements be made in the shop.

During the past few months the committee has been collecting data from the various railroad companies in order to arrive at some definite conclusions regarding existing practice. A letter of inquiry was also addressed to the various valve manufacturers and to the locomotive builders. The replies from some twenty railroads show that the safety valves now in use are of sufficient capacity, and on these reports the committee has based the calculations that are to follow. The records from twelve important roads show that the lift of the valves varies from 1/32 inch to 1/10 inch.

Taking the mean effective area of opening in square inches per 500 square feet of heating surface, based on existing average practice of twelve railroads, we have developed the following empirical formula:

$$A = \frac{0.10266 \times H.S.}{P}$$

Where A equals the effective area of opening of the valve in square inches, $H.S.$ equals the heating surface of boiler in square feet, and P equals the absolute pressure, or gage pressure plus 14.7 pounds. The formula is based on an evaporation of 5.28 pounds of water per square foot of heating surface per hour, and it is recommended for use in the application of safety valves until such time as it is shown to be in error or, upon future investigation, a better one shall have been devised.

The valves of nine prominent valve manufacturers show a lift ranging from .03 inch up to .15 inch; taking an average of these lifts (0.087 inch) and working out the values for typical modern switching, freight and passenger locomotives, the following tabulation is given illustrating the application of the empirical formula:

Type of Locomotive.	Service.	Heating Surface, Square Feet.	Gage Pressure.	No. and Size of Valves.
Pacific	Passenger	3,500	200	3—3½ inch.
Consolidation	Freight	3,200	200	3—3½ inch.
6-wheel switch	Yard	1,900	200	2—3½ inch.

In this tabulation it will be seen that the number and size of safety valves for the Pacific and consolidation type locomotives are the same. It is recommended that the railway companies adopt one standard size of safety valve for all their locomotives, and not have, say, two 3-inch and one 3½-inch valve on the same locomotive. The adoption by railroads of one size of safety valve for all locomotives will bring about a uniformity that is much to be desired. The valves shown in the tabulation are assumed to have forty-five degree seats.

[The above constitutes a majority report by the committee to which this topic was assigned. One member of the committee differing radically from his colleagues presented the following minority report.—ED.]

The writer has declined to sign the report of the committee appointed to collect data on the sizes and capacity of safety valves and to suggest methods for carrying out tests to determine the data in connection therewith, for the following reasons:

First.—Because there is given a definite recommendation founded on an empirical formula, that appeals to us as not having been proven as dependable.

Second.—Because a definite size of safety valves is recommended for given capacity boilers without regard to location, when the location of safety valves, to give desired results, is just as important as the size of the valves themselves.

Third.—Because of the further recommendation to use but one size of valves, regardless of the number that may be required on very large boilers.

Fourth.—Because, while a valve of a given diameter is suggested, no maximum lift, or free discharge, is recommended.

The committee has found this a large subject, and while a very important one, it is surprising what little valuable data are available; there are numbers of formulæ, generally quite old, and the majority evidently relate to stationary practice, and you will all coincide that there is a vast difference in the requirements for safety valves for stationary boilers and modern high-pressure locomotive boilers. Stationary boilers usually have large steam spaces, where valves can be conveniently and properly located, and it is seldom that the entire volume of steam being generated is held in check suddenly. With the locomotive the boiler is urged to its utmost capacity; the throttle instantly closed; the draft, caused by the speed of the engine, only partially stopped and often induced by the use of the blower to prevent the emission of smoke; hence the greater necessity of the use of correct size and properly located safety valves. Quite a number of these formulæ are worked out on a grate area basis, which is eminently wrong, because the effectiveness of the grate area is dependent on the kind of fuel used, varying from anthracite to high grade, gas-bituminous, and even to other fuels, such as crude oils and petroleums. Other authorities use the heating surface of the boiler as a constant, and with this as a basis the evaporative efficiency of the boilers must be considered, and it is here that we feel that we should be careful of our data.

The committee has used an evaporation of 5.28 pounds of water per square foot of heating surface, and recently constructed boilers, as brought out by the tests at St. Louis, have given over 12 pounds, or an increase of over 100 percent.

I think that you will agree with me that the proper location of safety valves is just as important as their size; there are numerous examples of valves located on shells of boilers, attached to contracted steam spaces, or that have been located on pipe connections, that have resulted in entrained water and fluctuation of pressure in contracted steam spaces which has destroyed the valves and failed to relieve the boilers; while the same sized valves, when properly relocated, have worked satisfactorily.

In connection with the third reason, the writer objects to the use of more than two safety valves, when they can be had of sufficient capacity to relieve the boiler, believing the cost and care necessitated in maintaining them will more than offset the advantage of maintaining but one size. Each valve should be of sufficient capacity to generally relieve the boiler under ordinary working conditions; the second valve should be provided to take care of extraordinary or unusual conditions and should only come into play sufficiently often to insure its being kept in working condition. In other words, we should use two safety valves for the same reason that we use two injectors, one to supply the boiler ordinarily, the second as a relief in case of failure of the first or upon extraordinary momentary duty being placed on the boiler.

The writer feels, in view of the great importance of this subject and the small amount of absolutely accurate information that the committee has been able to gather this year, that the committee should be continued; and its scope should be increased to cover the subject of safety valves generally, muffled as well as open valves, and particularly to make recommendations, in addition to the capacity of the safety valves, for their location; that they be authorized to conduct tests to determine if any of the rules that are now in force are correct and if not to formulate such rules as will provide us all with good working basis. While the diameter by which safety valves are now usually ordered is quite important, a more important fact is the real area of outlet, and the size of this outlet wil be governed not only by the foregoing conclusions, but also by the pressure that the boilers carry.

Testing Stay-Bolts.

Failure of stay-bolts is usually caused by the vibration of the bolt, although the exact cause of the vibration is somewhat in doubt. It is very evident that the bolt is bent in one direction each time the boiler is fired up, and again in the opposite direction when the fire is knocked and the boiler cooled off. This is, of course, due to the fact that the high temperature of the fire causes the inside fire-box sheets to expand more than the outside wrapper sheets, thus displacing one end of the bolt more than the other. As the bolt is held rigidly in the outside sheet, this bending, due to the greater movement of the inside sheet, causes the bolt to be bent in much the same manner as a beam which is fixed at one end and loaded at the other. This, of course, causes an excessive

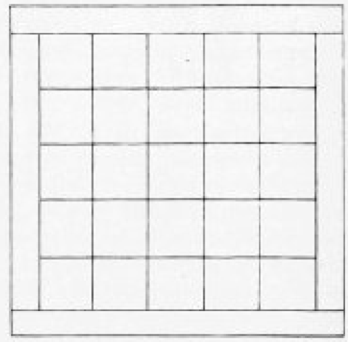


FIG. 1.—METHOD RECOMMENDED FOR PILING STAY-BOLT IRON.

tensile stress on one side of the bolt, due to the bending action in addition to the direct tensile stress, due to the pressure of the steam between the plates. If, however, this were the only vibration which occurred it will be seen that the number of such vibrations is comparatively small, and the failure of the bolt would not be expected to occur until long after it actually does in service. Therefore, many put forward the claim that there is a continual vibration, due to slight changes in the temperature of the fire-box sheets, or to slight changes in pressure in the boiler, causing what might be termed "pulsations." Whatever the cause may be, the nature of the fracture and its position on the broken bolt lead to the inevitable conclusion that the breakage is due primarily to vibration of the bolt. Therefore, in manufacturing stay-bolts it is necessary to produce a bar which can best withstand this vibratory action, and in the specifications for stay-bolt iron it seems reasonable to impose some sort of a vibratory test which shall approach as nearly as possible the conditions existing in a boiler in service.

Stay-bolt iron is usually rolled by some method of piling. In 1905 the Committee on Stay-bolt Specifications of the American Society for Testing Materials submitted for the consideration of the Society some new specifications for stay-bolt iron, and in these specifications the method of manufacture was specifically stated. This method was nothing new, as it had been thoroughly tried out by certain manufacturers, and had been found to give excellent results. The diagram, Fig. 1, gives an idea of the particular method of piling advocated by this committee. The specifications stated that all iron stay-bolts must be hammered or rolled from a bloom or pile having a minimum cross-sectional area of 45 square inches and a length of about 18 inches. The pile must be made up of a central core composed of bars of from ½ inch to 1 inch square, and shall be covered on all four sides with an envelope of plate ⅝ inch thick. This pile must be rolled

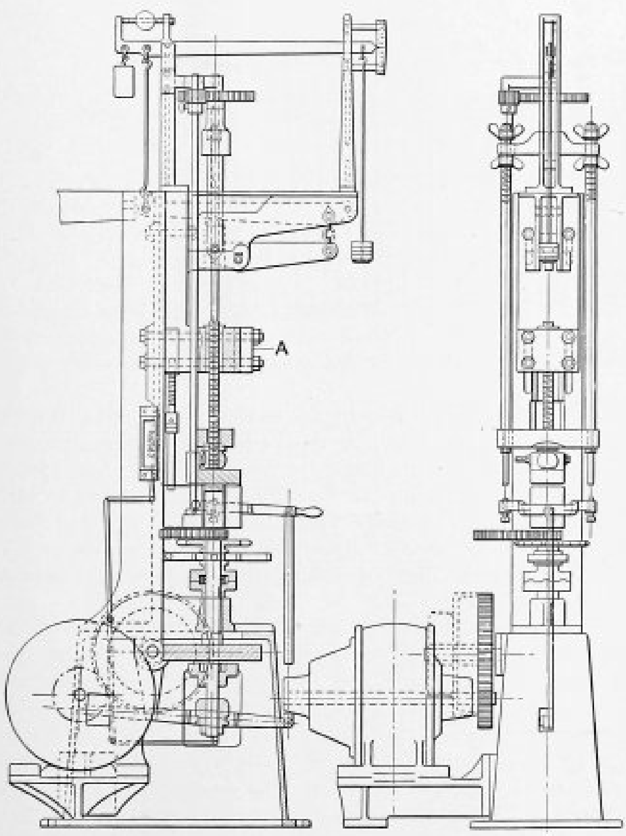


FIG. 2.—SECTION OF OLSEN STAY-BOLT TESTING MACHINE.

to a billet, allowed to cool, again heated, and then rolled into bars of the required dimensions. The diagram shows in cross section a pile composed of a central core of twenty-five small square bars surrounded by thin plates.

Continued observation of stay-bolts in service has established the fact that the bolts nearly always fail close to the outside sheet, the fracture starting from the base of the thread and gradually extending inward. The method of piling just described was devised for the purpose of preventing such a fracture from extending an appreciable distance into the bolt; the outside envelope of plate serving to give a surface in which good, sound threads may be cut, while the fibrous inner core, formed of small bars, tends to prevent the extension of any crack which starts on the surface or from the base of a thread on the bolt. Tests of stay-bolt iron

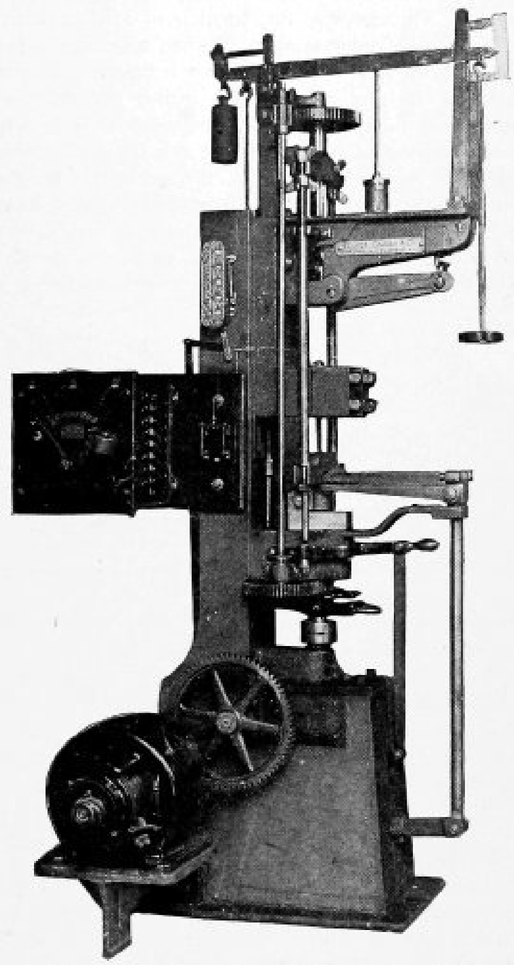


FIG. 3.—A VIBRATORY STAY-BOLT TESTING MACHINE.

manufactured in this way have shown that this method of manufacture successfully meets these requirements.

While some method of piling should undoubtedly be used for stay-bolt iron, yet this is not the only successful method of piling, and, as other manufacturers are accomplishing the same results by their own methods, it has, as yet, been deemed unwise to specify in the specifications for stay-bolt iron the exact method of manufacture. It has been thought that if a sufficiently severe vibratory test could be imposed it would be unnecessary to specify the method of manufacture, since only that iron which was piled in some satisfactory manner would probably withstand such tests. Up to the present time, however, vibratory tests on iron and steel bars have proved unsatisfactory, for the reason that no two testing machines will give the same results for the same grade of iron, and that it is oftentimes hard to obtain similar results from different tests on the same machine.

At the same time that the Committee on Stay-bolt Specifications of the Society for Testing Materials proposed specifying the method of manufacture they also proposed the following vibratory test, viz.: that the bolt shall stand a minimum of 6,000 vibrations when subjected to the following test: A threaded specimen, fixed at one end, has the other end moved in a circular path while stressed with a tensile load of 4,000 pounds; the circular path to have a radius of 3/32 inch at a point 8 inches from the end of the specimen. Therefore, nearly all stay-bolt testing machines are designed to hold one end of the bolt fixed while the other end is moved in a circular path, the bolt meantime to be placed under a tensile stress of from 2,000 to 4,000 pounds. One of these machines is shown in Fig. 2. The machine, which is the product of Tinius Olsen & Company, Philadelphia, Pa., consists of a base, to which is bolted an upright containing a rotating axle and means for applying the eccentric roll. A bracket is bolted to the upright, which has a shifting motion of 3 inches vertically, so that specimens may be vibrated in lengths of from 5 to 8 inches; the weighing system is also held in this bracket.

Looking at the line drawing of the machine, Fig. 3, it will be seen that the specimen to be tested is clamped in a head at "*A*," while the lower end is connected firmly to a ball around which the eccentric bearing rotates. The lever in front of the machine is raised to start the machine in operation, and upon the rupture of the specimen this is automatically thrown out and the machine stopped. The scale at the top of the machine is graduated to 1/1,000 inch, so that by taking readings from this scale, denoting the stretch of the specimen and the corresponding number of revolutions of the bearing a stress-strain diagram may be plotted which is exceedingly interesting, indicating at just what point the rupture begins to occur, and the resistance between this point and the final parting of the specimen.

The standard threaded stay-bolt is gripped in this machine without any further preparation, as the ball has a taper thread to insure a tight fit, and the upper head has liners threaded to the lower 1½ inches and straight for the remaining distance, thus allowing for the stretch of the thread, due to its being put on with a die.

With such a machine as that described above it is possible to get the regular vibration of the specimen, which brings alternately on one side of the bolt first a tension stress and then a compression stress. Whether this is anything like the action which goes on in the fire-box of a boiler, or whether the stresses thus produced approximate in intensity and frequency those which occur while the bolt is actually in service, cannot very well be determined. The vibratory test, on the whole, is a rather unsatisfactory criterion for the strength and endurance of stay-bolts. In fact, it is claimed by many that, if the following physical tests are specified, the iron can safely be accepted for stay-bolts without the necessity of any vibratory tests. The tensile strength should not be less than 48,000 pounds per square inch; the elongation in 8 inches not less than 28 percent; the reduction of area not less than 45 percent; the specimen should stand a double bending test close in both directions without flaw, and it should permit of the cutting of a clear, sharp thread.

Correct Layout of a Gusset Plate.

BY S. W. PURY.

In the March, 1906, issue of THE BOILER MAKER is an article describing the layout of a gusset plate, by T. J. M'Dermott. The method described in this article is entirely correct until it comes to the matter of laying out the pattern. Figs. 1, 2 and 3 show the problem as solved by Mr. M'Dermott. In Fig. 2 the parallel lines are spaced equal distances apart. The line *A-N*, the center line of the pattern of the gusset plate, is the development of the line A_2 N_2, shown in Fig. 1. It can readily be seen that the parallel lines *m-o*, *l-z*, *k-y*, *j-x*, etc., Fig. 1, do not divide the line A_2 N_2 into equal spaces. The space A_2 B_2 is smaller than the space B_2 C_2, and in turn the space B_2 C_2 is smaller than the space C_2 D_2, and these unequal spaces should be laid out their exact size on the center line *A-N*, Fig. 2, to locate the position of the parallel lines correctly.

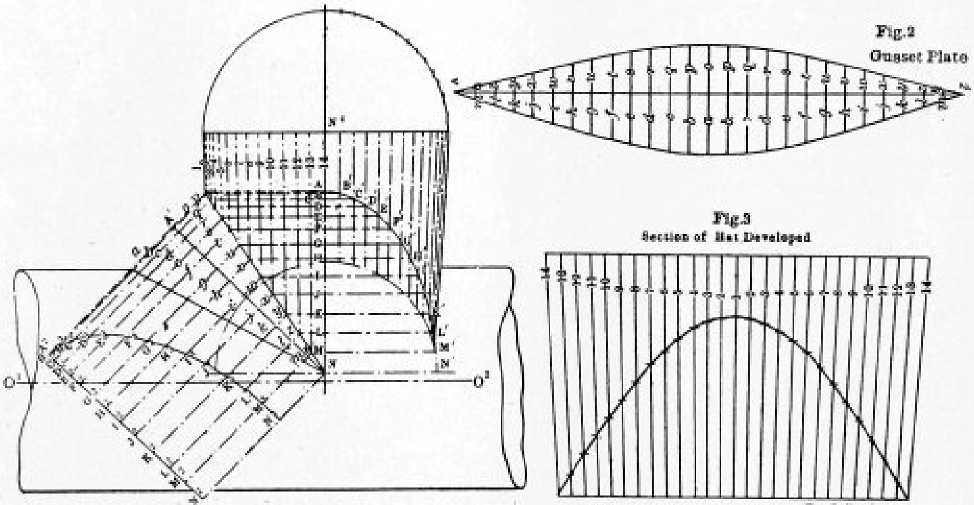
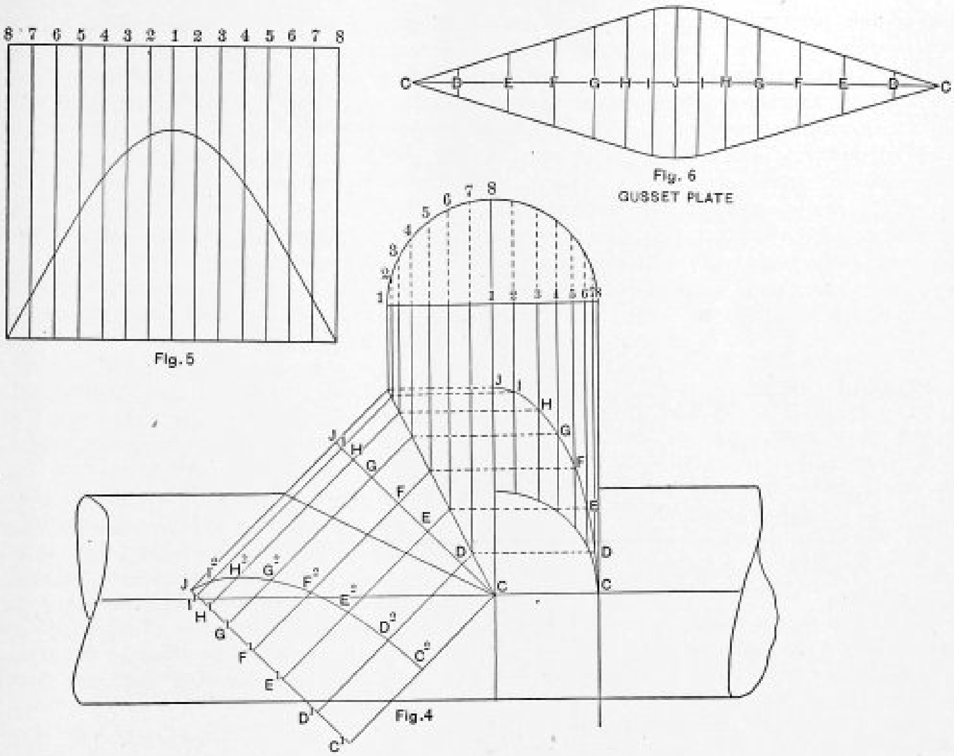


Fig.1

INCORRECT WAY OF LAYING OUT GUSSET PLATE.

Figs. 4, 5 and 6 show the correct development of this sheet; that is, the spaces *J-I* on the center line *C-C*, Fig. 6, are equal to the space J-I_2, Fig. 1, and the spaces *I-H* on the center line *C-C*, Fig. 3, are equal to the space I_2 H_2, Fig. 1. This is an important point, as the gusset plate will not fit accurately unless the parallel lines in the pattern are laid out to correspond to the spaces in Fig. 1. The remainder of the layout, shown in Figs. 4, 5 and 6, is the same as that shown in Figs. 1, 2 and 3, with the exception that the connection piece is not tapered, the diameter of the lower end being equal to the diameter of the main pipe. It was stated in the article, as originally published, that it is customary in order to avoid weakening the main pipe too much to reduce the diameter of the connection at the point where it intersects the main pipe, making it taper proportionately. The connection will then not come down as far as the center of the main pipe. This is a method which is invariably used in gas mains or furnace pipe.



CORRECT WAY OF LAYING OUT GUSSET PLATE.

Why an Overheated Boiler Plate Bags.

It is well known that beyond a certain temperature steel begins to lose its strength and receive a corresponding increase in ductility, or, in common language, the metal becomes soft. At a temperature of between 2,500 and 2,700 degrees F. mild steel becomes fluid. So long as there is an opportunity that a mild steel boiler plate, which is subjected to a furnace temperature of perhaps 7,000 degrees F., may become uncovered by the water inside the boiler, so that there is no means of conducting away the great amount of heat generated in the furnace, it is of importance to know just what percentage of its strength the plate loses with a certain rise of temperature.

An exact determination of this point has recently been made by Mr. C. C. Stutz, and the results of his experiments are shown in the diagram. This diagram shows the loss in ultimate strength of hard, medium and mild steel for a temperature ranging from 32 to 2,552 degrees F.; that is, from the freezing point of water to the melting point of steel, expressed in percent of its strength at ordinary temperature. The proportion of the ultimate strength as ordinarily given, that is, at ordinary temperature, represented by this percentage, is the remaining strength.

From the curve it will be seen that the strength begins to decrease very slightly at a temperature of 400 degrees F.; at 600 degrees, 10 percent of the strength is gone; at 700 degrees, 30 percent is gone, and the drop is very rapid up to 1,000 degrees, at which temperature only 30 percent of the original strength remains. The temperature of a thousand degrees, however, is below that of a dull, red heat, so that it is evident that steel even before it has become red hot may be only 30 percent as strong as it is at ordinary temperatures, and, therefore, it is easy to see how a plate unprotected by water, the fire side of which is exposed to a temperature of 6,000 to 7,000 degrees F., may quickly become almost red hot, and by so doing lose over two-thirds of its strength, and thus become

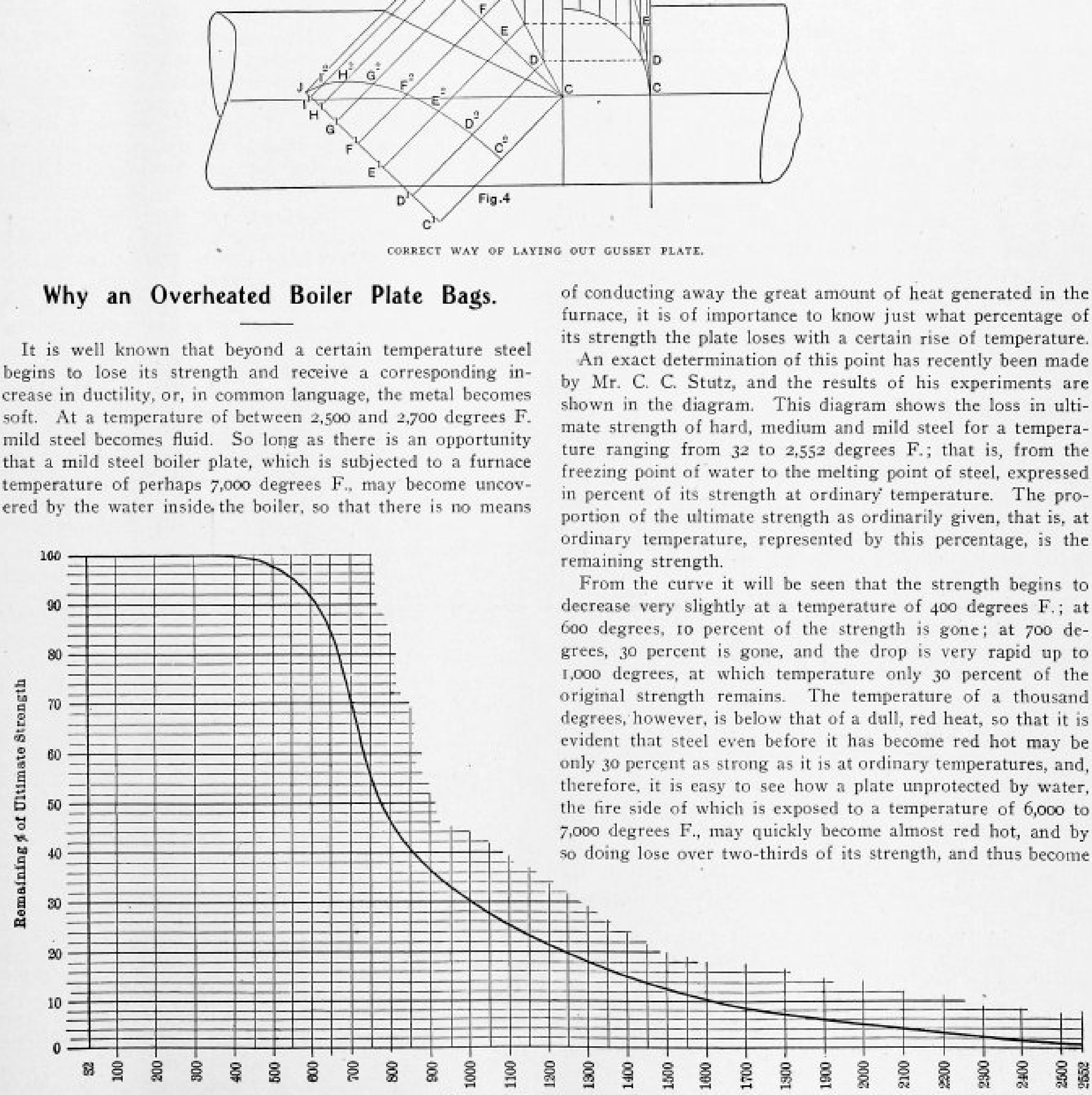


DIAGRAM SHOWING DECREASE OF THE ULTIMATE TENSILE STRENGTH OF MILD STEEL WITH INCREASED TEMPERATURE.

incapable of withstanding a pressure which it could withstand at ordinary temperatures.

The plate which becomes so weakened does not fracture like a piece of brittle steel, since there is a corresponding increase in its ductility, due to its rise in temperature. The increase in ductility at high temperatures has never been thoroughly investigated, and probably it would not pay to do so. It is this fact, however, which prevents many disastrous explosions; because, due to the increased ductility, the plate will bag and stretch before bursting, and a warning is thereby given, so that the pressure can be lowered on a boiler which has arrived at this dangerous condition.

Stay-Bolt Breakage.*

BY F. P. ROESCH.

The failure of stay-bolts is not always given the same prominence as the failure of flues, for the simple reason that a stay-bolt failure very seldom results in an engine failure, yet when we take into consideration the fact that as an item of expense in the care and maintenance of boilers the stay-bolt, especially on high-pressure boilers, runs the flue a close race, and in some localities is even more expensive, it is patent that from a dollar and cents point of view alone it is worth our every consideration.

Owing to the increase in steam pressure, together with the increase in boiler dimensions of the modern locomotive, the renewal of broken stay-bolts is becoming quite a serious matter; its expense is not so noticeable, however; where these bolts are cared for promptly and systematically as soon as they are discovered to be broken, the engine is seldom held out of service while renewals are being made; or if held, is held but a day or so, and not several days, as in a renewal of flues.

Eliminating the cost, and viewing the matter of broken stay-bolts simply as a question of safety, the problem is one of the most serious confronting mechanical men to-day.

Our knowledge of what really takes place in a modern locomotive boiler when in service is indeed limited; and while we may have all formed theories, few of which are based on actual knowledge, as to the cause and remedy for broken stay-bolts, yet our theories remain but theories, and absolute knowledge is as yet an unknown quantity.

The generally accepted theory for broken stay-bolts is, that the breakage is due to the vibration of the bolt, caused by the movement of the fire-box as it expands and contracts with the variations in temperature; the bolt being subject at the same time to a tensile strain of anywhere from 1,000 to 3,000 pounds.

Granting this theory as correct, so far as it goes, what causes this vibration or movement? The heating and cooling of the fire-box, you say? That is, every time an engine is fired up the fire-box, due to the expansion of the sheets, moves up, and of course carries the stay-bolt with it, and when the fire is again drawn and the box cools off, it returns to its former position, thereby causing a vibration.

Let us look into this theory to see how far it is borne out by facts.

Repeated vibratory tests of stay-bolt iron made at the instance of both the railroad companies and the various manufacturers, prove that a good, long-fibered piled iron will stand from 5,000 to 9,000 vibrations of one-sixteenth on either side of a common center; that is, that it will stand bending one-eighth of an inch from 5,000 to 9,000 times before breaking entirely, the iron being subject to a tensile strain of from 2,000 to 4,000 pounds average as found, but cases have been frequently noted while making tests, where the stay-bolt was not screwed tight into the outer sheet, where over 200,000 vibrations were obtained. Taking the lowest figure, however, 5,000; if we only obtained a vibration every time the boiler was fired up and the fire again knocked, and, assuming that the engine is fired up once every day, we would get but 365 vibrations per year, and consequently it would take at least fourteen years to break a stay-bolt. This we know to be absolutely wrong, as too many can bear witness.

The theory has been advanced that it is not necessary to knock a fire in order to produce a vibration, but that every change in steam pressure produces a corresponding change in temperature in the fire-box sheets, this change causing an expansion and contraction sufficient to produce a vibration.

Let us look into this theory. Assuming that the sheets have approximately the same temperature as the fire-box gases, which while the engine is in service, that is, on the road between terminals, will vary from 1,500 to 2,100 degrees F. After a sheet of iron as thin as a side sheet has been heated to 1,500 degrees, the addition of 600 degrees will make no perceptible difference in its elongation or expansion.

If we take the water side as indicating the temperature of the side sheets, we would have a variation of but 48 degrees to correspond to a variation of 100 pounds of steam pressure; and, again, this would be offset by the expansion of the outer or wrapper sheets, assuming that these sheets expanded in the same direction. This would indicate that this theory of accounting for the vibration of stay-bolts is not tenable.

Again, we have what are commonly termed breaking zones; that is, a certain part or parts of a boiler, or a certain location, where bolts break more frequently than at any other point. If the breakage of bolts is due solely to expansion, why do they break more frequently at one point than another? The expansion is equal!

The advocates of the expansion theory claim this is due to the greater rigidity of the outer sheets at these particular points. The cut shows what is usually termed the breaking zone in a side sheet. We will admit that rigidity of the outer sheet has some bearing on the subject, but that it is not the only factor is proved by the fact that the breakage of stay-bolts immediately above the mud-ring, or behind expansion pads, does not occur as frequently as should obtain, were this the only cause.

The writer had occasion to examine many boilers which failed through various causes during the past eight years, and during the course of his examinations made a careful study of the stay-bolt feature, noting, where possible, the average length of time the boiler was in service before the bolts began to show indications of fractures, also noting at what particular point of the bolt the fracture first started; that is, whether it started from the bottom, top, front or back.

As there has been quite a forward stride in boilers since 1900 we will only speak of those of later construction, say high-pressure boilers built since 1903.

In examining some of these we found that the stay-bolts in the side and throat sheets invariably began to break from the bottom; thus showing an upward movement of the fire-box, so that the bolt was in compression on its upper side and in tension on its lower side. This would go far to prove the case for the advocates of the expansion theory were it not for another curious fact noticed, viz.: *all the belly brace bolts and belly braces began to break, or, in other words, showed fractures at the top or upper side*, which would indicate that either the boiler moved up, or that the fire-box moved down, at this particular point, either of which effects are manifestly impossible.

It was further noticed that although many of the boilers had been in service less than two years, that quite a number of stay-bolt renewals had been found necessary, and in one

*By courtesy Railway and Locomotive Engineering.

case noted where a boiler was cut apart for the purpose of thorough study and investigation, and although the boiler had not been in service five years, there were but few bolts in the entire installation, with the exception of the long radials, but what showed the beginning of a fracture. It is true that the fracture was slight in many cases, not exceeding more than from 1/16 inch to 1/8 inch into the bolt, but others were found where the fracture extended half way through. All the bolts were of a very high grade ductile iron, having a tensile strength of 50,000 pounds per square inch and a high percent of elongation. This boiler had been running in what is termed a good water district, and is therefore a good example of the average life of a stay-bolt under favorable conditions to-day.

In a series of careful observations in the West in what is termed, and really is, a bad water district, it was found that the average life of stay-bolts in high-pressure boilers, 200 pounds and over, was considerably less than five years, and the question naturally arose, why? Why should there be a difference in the life of stay-bolts in a good and a bad water territory, especially when the failure of the bolts was due solely to breakage, and not to any pitting, corrosion, or other chemical action of the water referred to?

As stated in the beginning of this paper, the vibratory tests of stay-bolts showed that if a bolt was slightly loose in the outer sheet it would stand double and triple the number of vibrations that a tight bolt would.

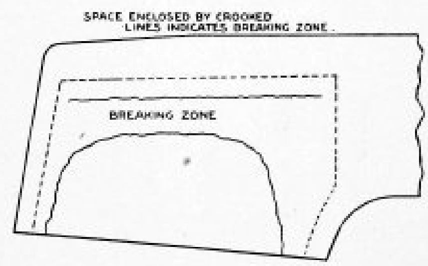
We know that in applying stay-bolts we do not depend on the fit of the bolt to make it steam tight, but prevent leakage by hammering up the ends. This hammering simply upsets the outer end of the bolt; that is, the end projecting through the sheet, and consequently if the bolt was screwed in loose enough to shake, the hammering or upsetting will simply make it tight in the outside of the sheet and leave it loose on the inside, consequently it is free to vibrate in the hole without leaking, and without putting the same vibratory strain on the bolt that would obtain were the bolt perfectly tight in the sheet through its entire thickness.

It is a known fact that where there is any slight leak about a boiler or any joint or seam that is not perfectly tight, any solids held in suspension in the water will invariably gravitate toward the leak or opening. In good water such sediment is soft and easily removed and therefore the sediment collecting between a loose fitting stay-bolt and the sheet offers little resistance to vibration. In a bad water district, however, this sediment soon bakes hard as the iron itself, and therefore a stay-bolt which was originally slightly loose in the sheet soon becomes absolutely rigid, and all vibratory stresses must of necessity be absorbed in the bolt. This has been proved to be the logical reason why stay-bolts have a seemingly shorter life in bad than in good water districts, as it was found where measures were taken to prevent incrustation by precipitating the solids in the form of a sludge and removing this by blowing it out, the life of the stay-bolts was materially lengthened.

This brings us back to our subject matter, "The Care of Boilers," and what we can do by increased care or change in present methods of caring for boilers, to prevent, or if not prevent, at least to decrease the breakage of stay-bolts.

Careful investigation has shown that where the bolt was originally screwed in straight, without any tension being applied in the installation, that as the fire-box moves upward it puts the upper part of the bolt, where it is screwed into the outside sheet, in compression, at the same time the under side of the bolt is in tension. (In speaking of the upper and under side of the bolt, we refer in relation to the mud-ring. That side of the bolt toward the mud-ring being termed the under side.) As the fire-box is returned to its original position, either through contraction in cooling, or other causes, the fiber in the lower half of the bolt, having been in a measure distorted even though but infinitesimally, is now slightly in compression, and this being repeated hundreds of times finally produces what may be termed a crystallization of the iron, but in the lower half of the bolt only, and eventually starting a fracture until at some time when the boiler is being abnormally forced, resulting in a high degree of expansion of the fire-box sheets and a high tension on the stay-bolts, due to the high pressure, complete rupture of the bolt takes place. This theory is proved by the fact that all stay-bolts which are but partially broken or fractured, show a short crystalline fracture where originally cracked, but if the bolt be now entirely broken the rest of the area of the bolt will show a long, fibrous fracture.

The only exception noted of bolts starting to break from the bottom, was in cases where the bolt was screwed into a double thickness in the outer sheet, or in some rigid corners; in these instances it was noticed that after the fracture had



THE BREAKING ZONE FOR STAY-BOLTS IN A SIDE SHEET.

extended about half way through from the bottom, that the bolt began to show indications of fracture from the top, a fracture to the depth of about one-sixteenth to three thirty-secondths of an inch being noted, extending all the way round the unbroken or upper half of the semi-circumference of the bolt.

Therefore, to decrease breakage where rigid bolts are used, we would suggest that while the bolt be made a tight fit in the inner or fire-box sheets, it be left slightly loose in the outer or wrapper sheet, depending on the upsetting to make it steam tight. Further, that in bad water districts means be adopted to prevent as far as possible, incrustation, so as to allow the bolt to retain a measure of flexibility in the outer sheet. That boilers be cooled off, or fires knocked only when absolutely necessary, and then slowly to prevent rapid and extreme changes in temperature, and last, when a bolt is found to be broken, remove it, to prevent an excessive strain on the neighboring bolts, thereby shortening their term of service.

Now a word in regard to a theory as to one of the causes of stay-bolt breakage.

It is hardly reasonable to suppose that a bolt which will stand from 5,000 to 9,000 vibrations in a vibrating machine will, if applied to a boiler, break after but 500 or 600 vibrations, and yet we must accept this as correct if we assume that the breakage is due to the vibrations and tensile strain (which is correct beyond a doubt), and that the vibrations are caused by the variations in temperature, causing an unequal expansion and contraction between the inner and outer sheets.

If this were the correct solution, why did we not have the same trouble with broken stay-bolts years ago that obtain to-day? We had the same expansion and generally shorter bolts, consequently the angle of vibration would have been greater, and consequently more destructive to the iron fibers; each bolt sustained practically the same tensile strain per square inch of bolt area, as although the pressure was less the bolts were smaller and spaced farther apart. Do not understand me to say that we had no broken bolts in the olden days, because we had them, but we did not have as many in proportion to the number of bolts in a boiler as we have to-day.

There is but one other theory that we can advance that will explain the increased breakage of stay-bolts, and at the same time explain why the stay-bolts begin to break from the bottom, showing an upward movement of the fire-box, while the throat-sheet belly braces break from the top, showing an upward movement of the belly of the boiler; and that is, owing to the reduced steam space and increased throttle, dry the fire-box. We therefore have the two forces acting one against the other, the heat expanding the fire-box, while the steam pressure is trying to collapse or compress it.

It is virtually a battle of the giants. Is it not reasonable, therefore, to assume that as each cylinder volume of steam is withdrawn from the boiler the pressure is momentarily relieved, not necessarily in pounds, but only in fractions of a pound, and that these fractions of a pound multiplied by the area of the fire-box, relieve the compressive strain by just that amount, and the fire-box immediately responds to the

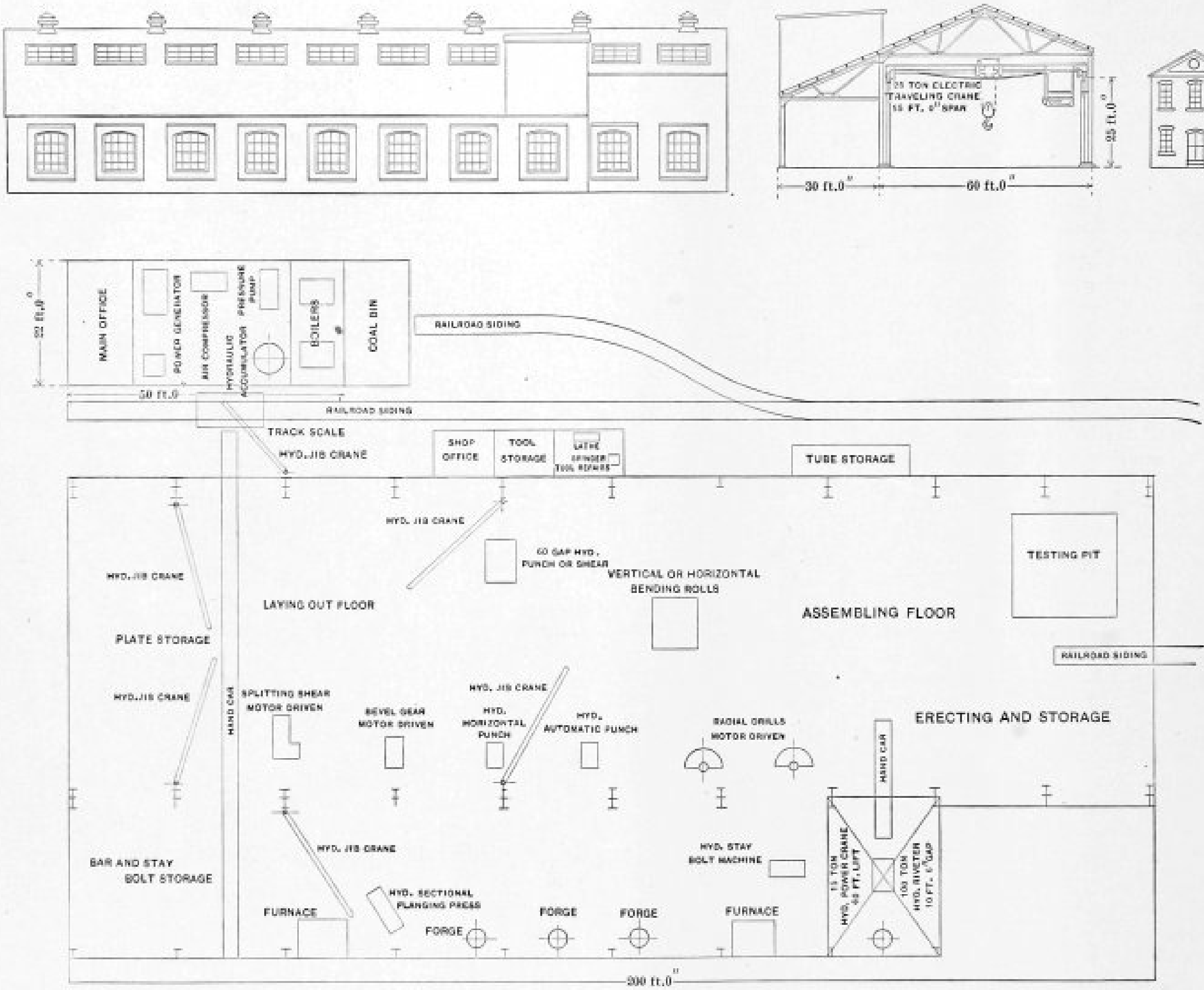


FIG. 24.—ARRANGEMENT OF A MODERN BOILER SHOP SHOWING LOCATION OF CRANES FOR HANDLING OF PLATES.

pipes and cylinder area of the modern engine as compared to the old-time engine, and also owing to the change in form of the boiler, especially the wide fire-box type, there is a constant pulsation going on in the boiler when the engine is laboring hard, causing an upward and downward movement of the fire-box and also an expansive and contractive movement of the cylindrical shell.

In order to understand this clearly, we know that as the fire-box sheets become heated they naturally expand; as the mud-ring prevents any downward movement the expansion is upward and endways, in fact the natural tendency of the fire-box is to become larger. As steam is generated, however, it begins to press in on the fire-box from all sides; at 200 pounds per square inch, you can easily see what an enormous pressure is being brought to bear on the outside of momentary relief in pressure and moves in the direction of least resistance, which is up. The cylindrical part of the boiler which is in tension momentarily contracts in its diameter; then as the heating surfaces again generate enough steam to replace the volume withdrawn the former conditions are restored and the fire-box is again in a state of what may be termed expansive compression, while the boiler is in a state of expansive tension, the whole process or action of the boiler while the engine is laboring hard being almost similar to a man breathing.

It would naturally follow, therefore, that an increase in boiler capacity, and especially in steam space as compared to cylinder volume, would considerably lighten our costs of boiler maintenance and reduce our boiler failures very materially.

Flanging Boiler Plates.—III.

BY FRANK B. KLEINHANS.

Handling Sheets.

However much can be said in favor of the large shop traveling crane for handling work, there is a certain class of work that it cannot do. The old-fashioned jib crane which was used exclusively years ago is the most convenient means for handling sheets in the shop. It must not be inferred that the traveling crane is not necessary in the flanging shop. There should be one or two traveling cranes of ample capacity to handle a pack of sheets; where the sheets are too long two such cranes are essential, but in addition to these cranes there should be a good service of jib cranes, and these preferably operated by power.

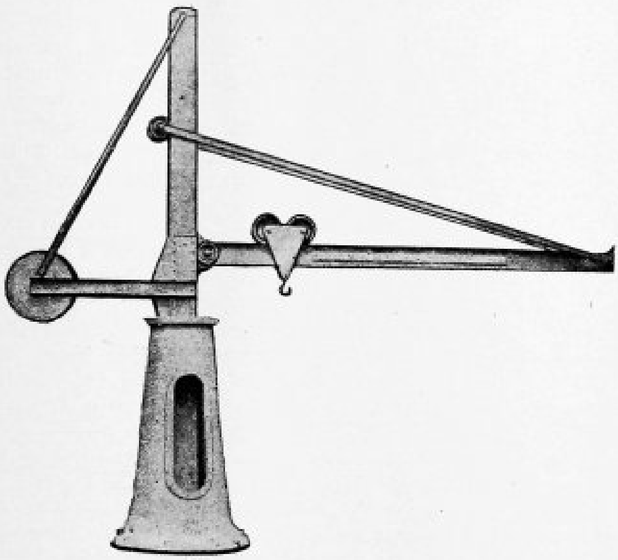


FIG. 25.—ALL-ROUND SWING CRANE.

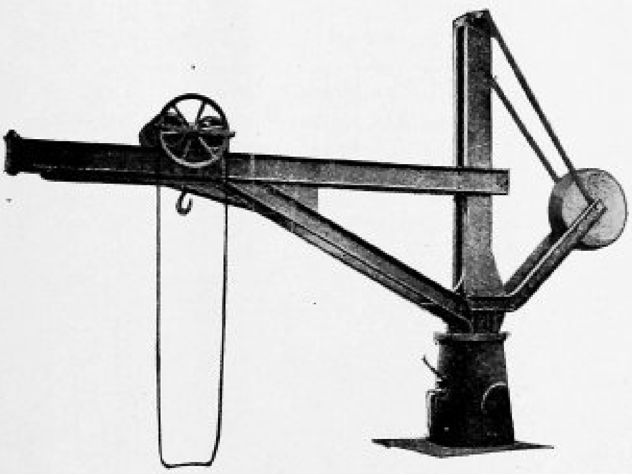


FIG. 26.—HEAVY HYDRAULIC JIB CRANE.

Fig. 24 will give a good idea of a modern boiler shop. The main building is supplied with a traveling crane and jib crane, as shown. The "lean-to" contains the furnaces, forges and sectional flanging press, also an hydraulic jib crane and a number of braket cranes. The office and power house are in a separate building, while the shop office, tool room, etc., are shown grouped together conveniently.

Fig. 25 shows an all-round swing crane, the arm of which is supported by a tie rod, thus giving clear space all around the column. The trolley is not provided with any means for racking it back and forth. It is provided with an hydraulic cylinder in the base, for raising and lowering. In Fig. 26 we have a heavier jib crane. The arm is here supported with a strut. The arm can thus be made very long and can reach a large radius. The crane is lifted by an hydraulic cylinder, most of which is underneath the floor.

Bracket cranes can be obtained to suit almost any requirement of lift or radius. Fig. 27 shows a structural shape, which has a trolley running along the top, and is not provided with any means for racking the trolley back and forth.

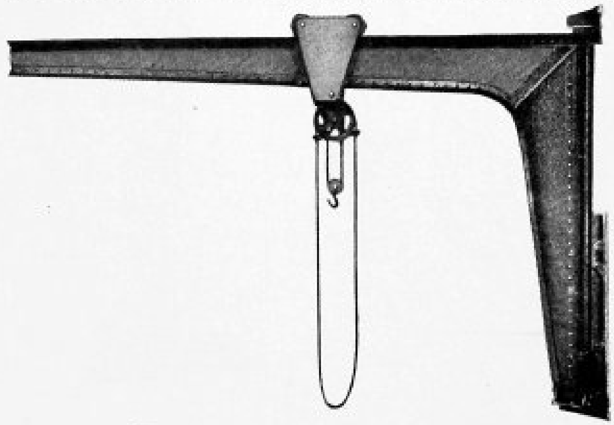


FIG. 27.—BRACKET WALL CRANE WITH CHAIN HOIST.

This is to be attached to a wall or building column, and will swing through only about a half circle. This bracket crane is not provided with power lift, but simply swings on two swivels. A chain hoist is used for raising and lowering the sheet in the fire or on the machine or die. A much heavier bracket crane is shown in Fig. 28. The jib is raised or lowered by means of an hydraulic cylinder, while the trolley has a hand movement only. The jib can be arranged to swing considerably more than a half circle.

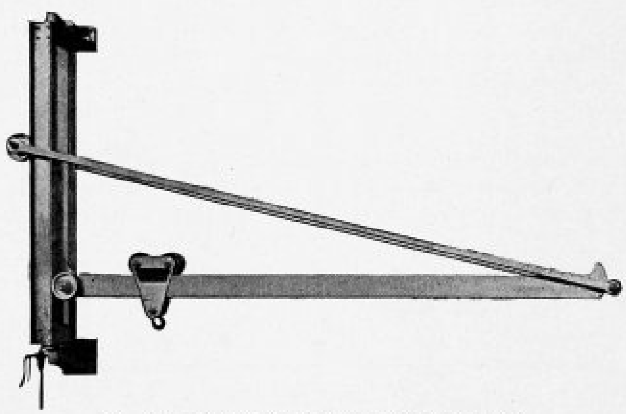


FIG. 28.—BRACKET CRANE WITH HYDRAULIC LIFT.

It might be well to mention a few things in connection with the piping of these cranes. In most boiler shops the line pressure is 1,500 pounds to the square inch, as this has been found to work to the best advantage on hydraulic presses, riveters, punches, etc. It is pretty difficult to keep large pipes tight at this pressure unless unusual care is taken. In a large boiler shop one good, experienced man can look after this work, but in a small boiler shop the trouble begins, since there is not enough work to keep one man busy, and so it gets to be every man's job, and consequently is not done right. If pipes of small diameter are used, say 1 inch, this will give sufficient speed for cranes and light machines, and you will eliminate the difficulty of leaky joints. Use plenty of lead on the threads and screw them up tight and they will keep tight.

All the cranes shown in the foregoing illustrations must

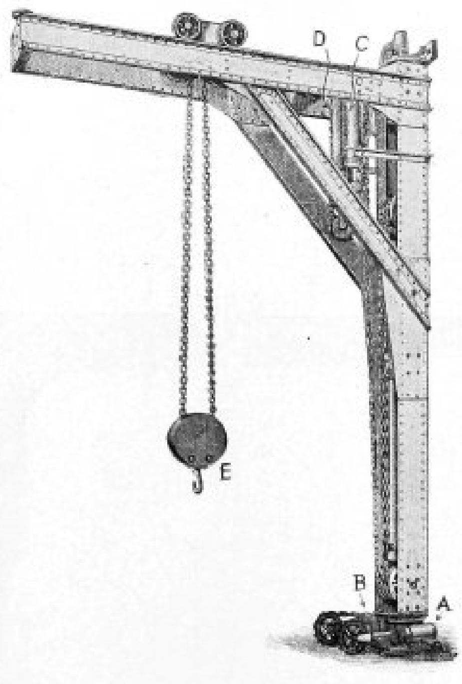


FIG. 29.—HEAVY CRANE OPERATED ENTIRELY BY HYDRAULIC POWER.

be pushed around by hand. This can be done easily with a single sheet, but when the load is very heavy it becomes very hard to drag the pieces around. Fig. 29 shows a heavy wall crane, which is provided with two cylinders *A* and *B*. The operating valve is a four-way valve, and when the water is turned on at *A*, for instance, it is exhausted from *B*, and then the crane is rotated. A pair of cylinders *C* and *D* are also provided for racking the trolley, while a large cylinder, through a multiplying sheave, raises and lowers the block *E*.

In flanging a sheet, as a rule, there are nearly always holes wanted in the flat portions for tubes, rivets or stays, and many of these holes are punched or drilled in the flat sheet. Into these holes clamps are attached for handling the sheets to and from the fire and in flanging. Fig. 30 shows a three-chain connection to a sheet which is being flanged under a sectional flanging press. This consists of a central ring *A*, onto which are connected three chains. These have a flat plate attached to the lower end (see detail, Fig. 32), with several holes. One or several bolts attach the foot to the sheet, depending on the weight of the sheet. The ring *A* is quite large, so that a crane hook can be slipped through it.

In handling sheets from the cars or from storage to the machine, the lifting hooks shown in Fig. 31 are used. A large ring is connected by chains or rods to the hooks, as shown. These are easily put on or taken off. For handling sheets vertically the clamp *C* shown in Fig. 34 is used. This will take a firm grip on a sheet, especially with a capped end

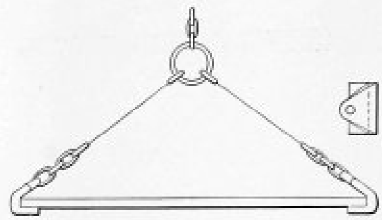


FIG. 31.

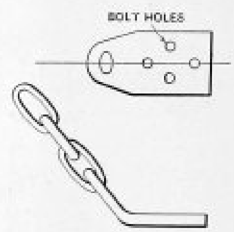


FIG. 32.

on the screw *S*. It has the advantage of holding, no matter what position the sheets get in, but requires a little time to put it on and take it off. Fig. 33 shows a lifting rig, in which the eccentric parts *E* and *F* will take a tight grip on the sheet, as the heavier the sheet the tighter the grip. It is put on quickly, and if in removing it sticks, a good thump on top will make it let loose.

Clamping Sheets.

It is almost impossible to flange sheets by hand without some sort of clamps. These may be the small screw clamps

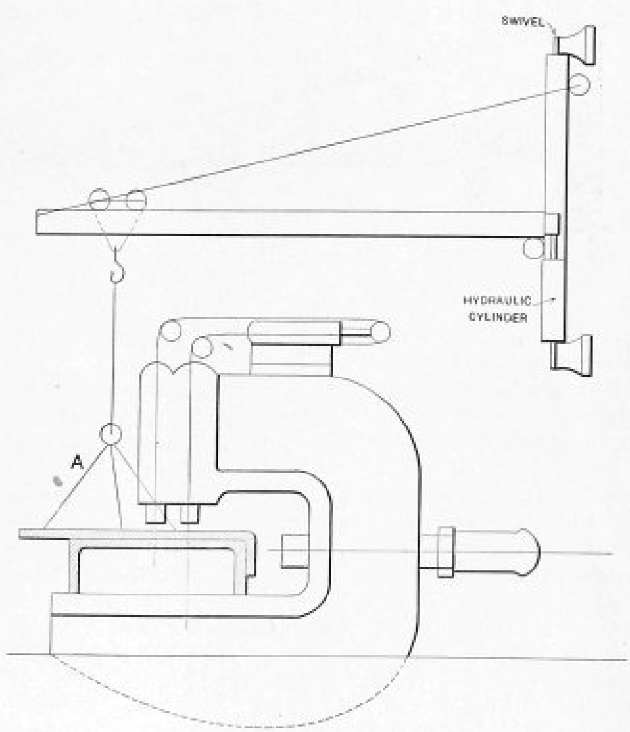


FIG. 30.—USUAL METHOD OF SUSPENDING SHEET AT FLANGING MACHINE.

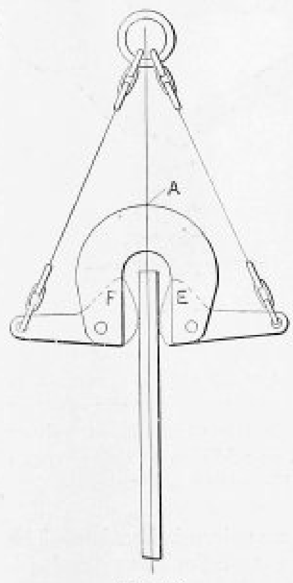


FIG. 33.

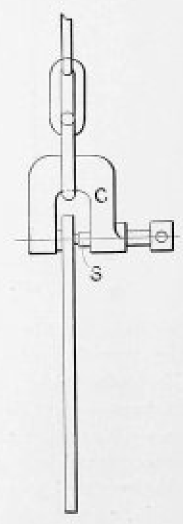


FIG. 34.

that have been shown in a previous issue, or they may be the heavier clamps, commonly known as flanging clamps. In Fig. 35 we have a very inexpensive clamp. The bottom beam has a foot cast on at *A* and *B* to serve as a means of bolting the clamp down. The screws have round heads forged on the bottom, which fit in pockets in the bottom beam. A brass

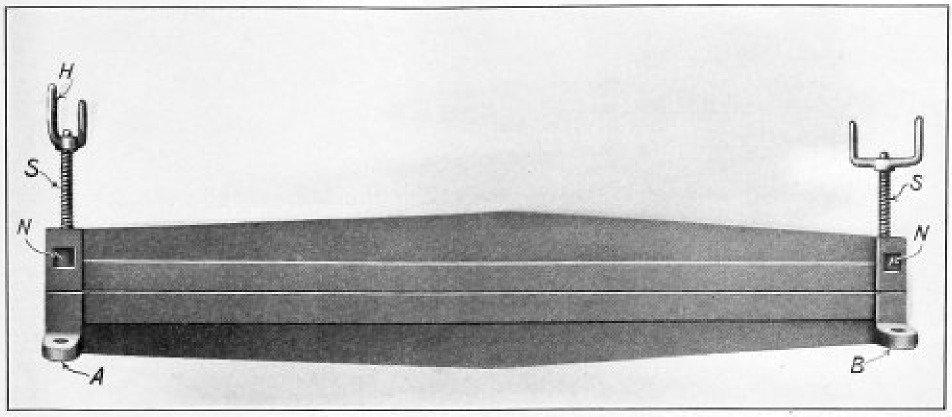


FIG. 35.—HAND-FLANGING CLAMPS.

nut *N* on each end is slipped in through a cored hole. The handles *H* are dropped over a square end on the top of the screw. The top and bottom beams are flanged, and have a ⅛-inch fillet on one side and ½-inch fillet on the other. This clamp works all right for single plates where the flange does not have to pass through the clamp.

A more substantial clamp for this class of work is shown in Fig. 37. The ends of the beams are carried in a housing, and this does away with the tendency of the top beam to tip. When the clamp is wide open it can be brought down over a flanged sheet and will still be very stiff. Fig. 36 shows such a sheet. The parts which have been flanged are in the clamp, and the sheet is held in position by a block. The die *D* would be clamped to the floor plate *F*. The hand wheels, Fig. 37, should be very heavy, otherwise the arms will be torn out by the bar when tightening up the screw.

There is an almost endless variety of ways that a sheet may be clamped for flanging, but the thing that controls the type to be used is the ease with which sheets can be clamped and removed. Any loss of time is a bad thing when we are handling a hot sheet. A heavy hand wheel of large diameter will accomplish this. There is a disadvantage in this, however, as it interferes with the workmen. A very quick scheme for operating the clamp is by means of compressed air. The operator then has only to throw a lever and the sheet is clamped almost instantly. Fig. 38 shows one of these clamps. The housing, etc., are similar to the hand-screw clamp. Fig. 39 shows another type of compressed air flanging clamp. One

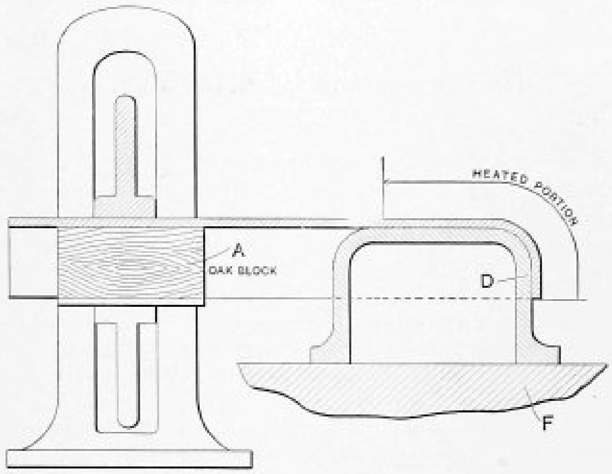


FIG. 36.

of the features of the cylinder is to have a leather packing ring on the piston instead of a metal packing ring. This prevents any undue loss of air, as the pressure remains on all the time the sheet is in the clamp.

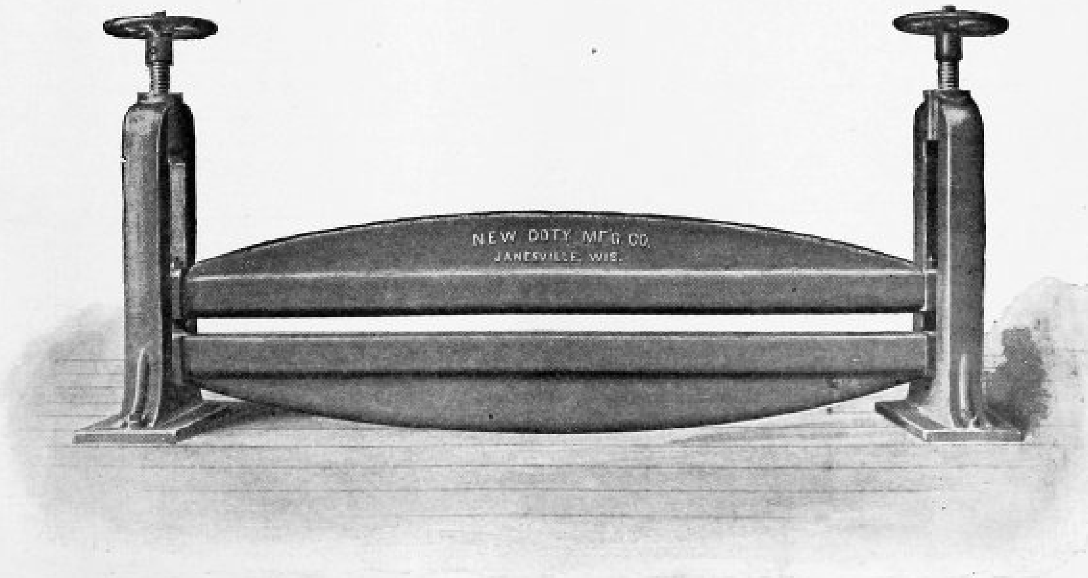


FIG. 37.—HAND CLAMPS WITH END HOUSINGS.

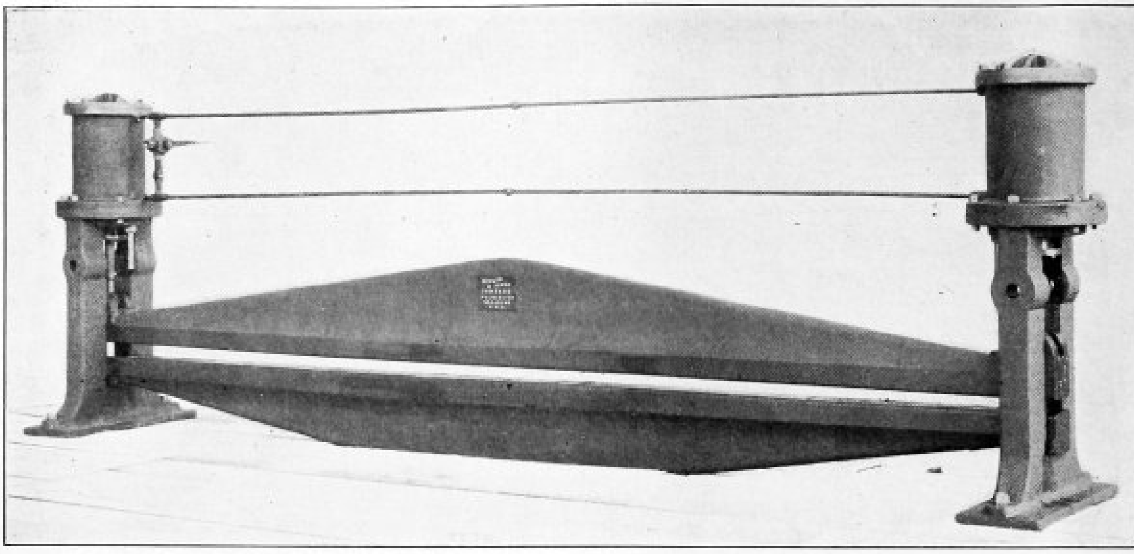


FIG. 38.—FLANGING CLAMPS OPERATED BY COMPRESSED AIR.

Development of a Meter Box.

BY G. W. SMITH.

A thousand meter boxes were to be made of cast iron 3/16 inch thick, and it was thought that a pattern of wood only 3/16 inch thick would hardly stand, since the entire lot were to be cast from one pattern. It was decided to make a pattern of 3/16-inch sheet steel with the lap scarfed so as to give the entire box a uniform thickness throughout. Great accuracy was required in the development of the pattern, as the boxes were to weigh exactly 78 pounds each, and there would have been a great loss of metal in casting if each one was a trifle over weight.

The elevation and plan of the box are shown in Figs. 1 and 2 respectively. All dimensions are taken from what are generally termed the "neutral lines" of the pattern; that is, the lines drawn at the center of the thickness of the material. By laying out the pattern to these lines the thickness of metal can be disregarded. On line 1'-8', Fig. 1, lay out the length of the base 20 3/16 inches. At a distance 23⅛ inches above this draw the line 1-8 parallel to it. The line 8-8' is inclined so that the point 8 is offset from the point 8' ½ inch, as shown in the plan. From point 8 at the top lay off the line 8-1, 10 5/16 inches long, and connect the point 1 with 1'. This completes the outline of Fig. 1.

Draw Fig. 2, as shown, although since both sides are the same it will be necessary to use only one-half of Fig. 2. Divide the semi-circle representing the upper end of the box into any number of equal divisions, in this case seven. Also divide the line representing the bottom of the box into the same number of divisions. Connect the corresponding points with solid and dotted lines, as shown. Project the points from the line that represents the base, in Fig. 2, up to the base line, Fig. 1. Describe a semi-circle above Fig. 1 and divide it into the same number of equal parts as the semi-circle in Fig. 2. Project these points of division down to the top of the box and connect these points with corresponding points on the bottom of the box with solid and dotted lines, as shown, care being taken to connect the points in the same order as in the plan, Fig. 2.

Extend the lines 8-1 and 8'-1' in Fig. 1 over to the line 0-0', Fig. 3, and from point 0', Fig. 3, lay out the length of the line 1-1 equal to 1-1' in Fig. 2; 1-2 equal to the line 1-2', Fig. 2; 2-2 equal to the line 2-2', Fig. 2; 2-3 equal to the line 2-3', Fig. 2, and so on, laying out all the solid lines on one side of 0-0' and all the dotted lines on the other side. Connect these points with 0. The lines thus drawn will be the true lengths of all the lines in the pattern.

To develop the pattern, start from the line 8-8' and work on each side. Draw a line of indefinite length and on it lay off the distance 8-8', as measured from Fig. 3. With dividers set to the length of one of the divisions on line 1'-2'-3'-4'-5',

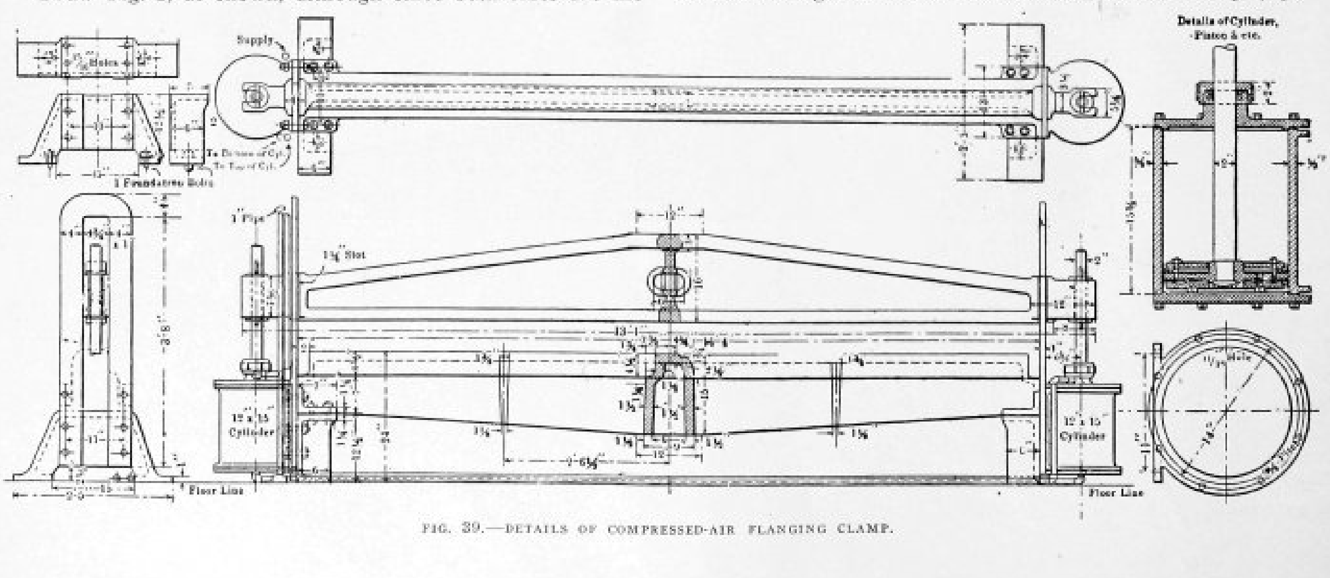
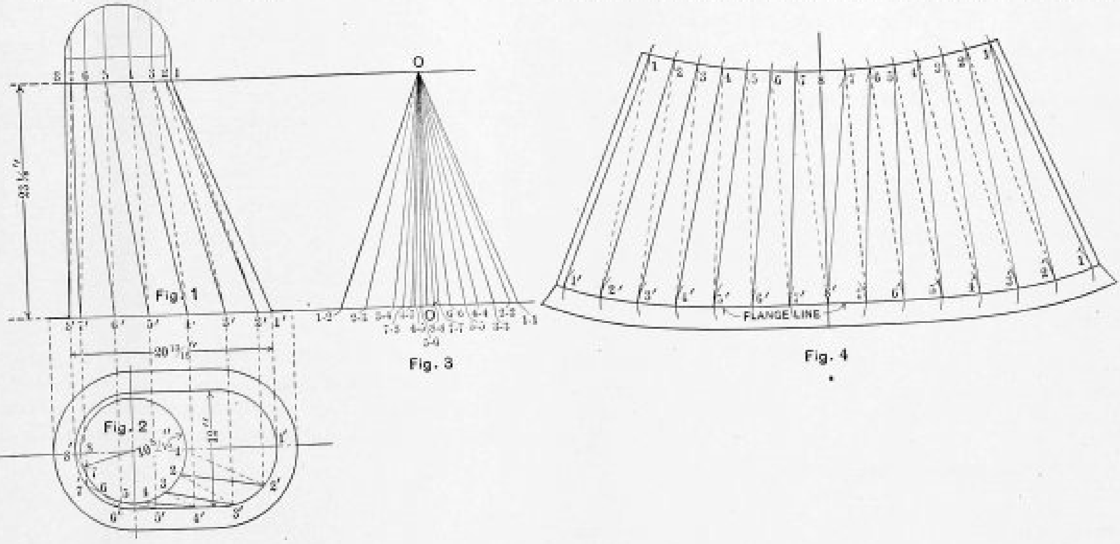


FIG. 39.—DETAILS OF COMPRESSED-AIR FLANGING CLAMP.

etc., Fig. 2, strike a small arc from point 8, Fig. 4. With 8′ as a center, and the trammels set to the length of the line 7-8, Fig. 3, strike another arc, cutting the arc previously made, which will locate the point 7. Repeat this operation on the other side of line 8-8′. With the dividers set to the length of one of the divisions in the semi-circle, Fig. 2, and with 8′, Fig. 4, as the center, strike a small arc. Set the trams to the length of the line 7-7, Fig. 3, and with point 7 as a center strike an arc cutting the arc previously made from point 7′. Connect this point and point 7 with a solid line. Proceed in a similar manner until lines 1-1′ have been drawn. Allow a sufficient amount for the lap, which is to be scarfed, and also add for the flange on the bottom of the pattern, as shown. It was necessary to use great care in flanging as well as in the development of the pattern, since it was required by the city inspector that the box should set as nearly perfect as possible. This is rather an unusual job for a boiler maker to handle, but it shows what accurate work can be done in laying out and flanging in the boiler shop.

interest would mean an expense of from $275 to $1,000 per year. The various systems reported are said to be entirely satisfactory; they can wash out and get ready for service twenty to twenty-six engines per twenty-four hours; the average time required to wash out and get an engine ready for service is from 55 1/3 minutes to 4 hours 15 minutes; the average time formerly taken was 3 to 6 hours. In all cases a very marked reduction was reported in flue leakage and broken stay-bolts, although very little exact data were available on this subject. At one point it has been possible to reduce the number of boiler makers employed from ten to four, due to decreased boiler work since the hot water washing-out system has been installed.

Some of the other benefits derived are given as follows: No evidence of steam in roundhouse; always plenty of water at 212 degrees to refill boilers; temperature of water reduces time and fuel necessary to get engine hot; facility in turning engines; reduction of engine failures, reducing overtime; reduction of time at terminals where washing out is necessary.



PLAN, ELEVATION, PATTERN AND DETAILS OF TRIANGULATION OF METER BOX.

Best System of Washing Out and Refilling Locomotive Boilers.*

The best system of washing out is one that will do the work properly, with the least change in temperature in boiler, at a minimum expenditure of heat, and in the shortest possible time. The fact that good results are obtained by having less trouble from fire-box and flue leakage, and a reduction in the number of stay-bolt breakages, and last, but not least, the reduction in terminal delays, would appear to warrant the expense of installation. The more nearly uniform the temperature is kept, the less expansion and contraction takes place, especially in the fire-box, which must reduce the vibration in stay-bolts and give them a correspondingly increased life. It has been demonstrated beyond a doubt that when a boiler is kept at a uniform temperature, the least trouble is experienced in the matter of leaking flues and fire-boxes.

In taking the question up with a number of superintendents of motive power, who are using various devices having the object of washing out, changing water and raising steam quickly, by the use of hot water, and live steam where necessary, the following information was gathered: There are four or five different systems which have been in use from one to three years. They cost from $5,500 to $20,000, depending on size and number of stalls equipped, which at 5 percent

*A report presented at the annual convention of Master Mechanics, June, 1908.

Probably the most important saving effected by the hot water changing or wash-out system, is the rapidity with which the work can be done; engines are ready for service from one to two hours quicker than could possibly be the case with a cold-water system, which necessitates cooling an engine down after the steam has been blown off, before the engine can be washed out, and then directly after bringing the water back to the high temperature; such waste of heat, which means coal, would not be tolerated under any other conditions, but takes place daily at hundreds of roundhouses in this country, without any protest.

A simple arrangement used on one of the Western roads with very great success, for utilizing steam and water otherwise wasted, is to have wells into which cold water flows from the main, or source of supply, and to heat it by steam and hot water from engines; from this place the water is pumped for washing out and filling boilers. This is probably the cheapest system for furnishing hot water, but has the objection that the water has been blown from dirty boilers; however, as only a boilerful is taken, it is soon diluted and rendered innocuous by the fresh water injected into it from the tank.

The following actual savings have been reported:

Decreased cost of washing boilers. In 1906 with cold water, for labor alone it cost $1.32 per boiler, whereas, with hot water in 1907, $1.01 was charged against this item, or on the road reporting it, a saving of $2,019.95 per year for labor alone, in washing boilers, was effected on an outlay of $6,000.

Decreased cost of water used. This item may not appear at first sight to amount to much, but where a saving of 7,000 gallons for each boiler washed out can be effected, as has been reported, this, at 7 cents per thousand gallons, in Chicago, amounts to 40 cents per boiler washed. It is the opinion of the committee, however, that this estimate of the amount of water saved is high.

Decreased amount of coal used. On one road this is given at 140 pounds per engine, which is probably low; this at $2 per ton would amount to 14 cents, so that with the three items mentioned we get a saving per engine of:

Labor	$0.31
Water	.49
Coal	.14
Total	$0.94

The saving of time at the roundhouse is probably, in busy seasons, more of an object than anything else mentioned, and as this amounts to cutting the time in half for washing out, it means, assuming that engine is not held for any other work, that with 1,000 engines, each turned two hours quicker than was possible with the cold-water system, you have a saving of 2,000 engine hours, and as engines generally have to be washed out once a week, or four times a month, in bad-water territory, it amounts to 8,000 engine hours a month, or 96,000 engine hours a year; this, if the engines have to be rented at $10 a day, which is a low figure for a large engine, in busy seasons, would cost $40,000; or, putting it another way, working 365 days of 12 hours each, it would require practically 22 additional engines to equal the 96,000 engine hours a year, which, at $15,000 per engine, would mean an expenditure of $330,000.

In conclusion, the committee recommends that boilers be washed out and filled with hot water; the savings obtained by doing so will pay a good interest, on the necessary investment.

Upsetting Stay Rods.

With the advent of modern high-pressure boilers and the corresponding change in boiler shop practice from the hand-tool methods of former days to the operation of heavy power machinery at the present time, has come a corresponding demand for increased mechanical ability among superintendents and shop foremen. Nearly every large up-to-date shop of the present day is equipped with either a four-column hydraulic flanging press or a hydraulic sectional flanging machine. A great variety of special work can be handled on these machines if only the man in charge of the shop is capable of designing the proper dies and formers.

This is a subject with which every foreman boiler maker ought to be familiar, as it is safe to say that a considerable amount of money is annually wasted experimenting on dies which fail to do the work for which they are intended and which eventually find their way to the scrap pile.

First, let us see how this work may be done on the sectional flanger. We have reproduced herewith some drawings showing dies which were designed a few years ago by one of our engineers for upsetting stay rods on this machine. The dies for doing this work on the sectional flanging machine are more economical than those for the four-column press.

Figs. 3 and 4 represent a sectional flanging machine arranged with two vertical rams in the top and a horizontal ram in the back. The vertical rams are used for raising and lowering the upper half of the die as well as to clamp the rod between them, while the horizontal ram is used to do the upsetting.

In Fig. 1, 1 represents the upper half of the die, while 2 in Fig. 1 shows the lower half. These are shown partly cut in two to show the stay rod after being upset. 3 in Fig. 1 is the horizontal ram; 4 in Fig. 1 the upsetting plunger; 5 in Fig. 2 the front view of the upper die, and 6 in Fig. 2 shows the front view of the lower half of same set in position on the flanging machine.

7 in Figs. 1 and 2 represents the connecting block between the dies and upper ram.

Fig. 4 represents the front view of a sectional flanging machine, with upsetting dies in position when the plungers are down and the rod clamped in position ready to be upset.

Fig. 3 shows the side view of a sectional flanging machine

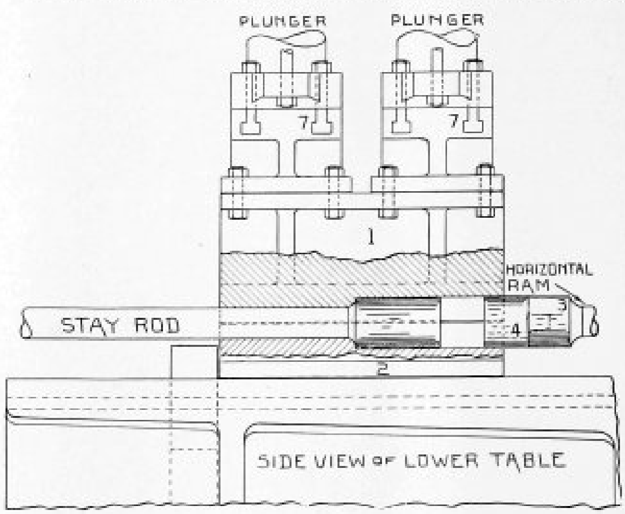


FIG. 1.

with the upper dies raised and the stay rod in position ready to be clamped and upset.

These two cuts show clearly how the dies are detached and used, while Figs. 1 and 2 show the construction in detail.

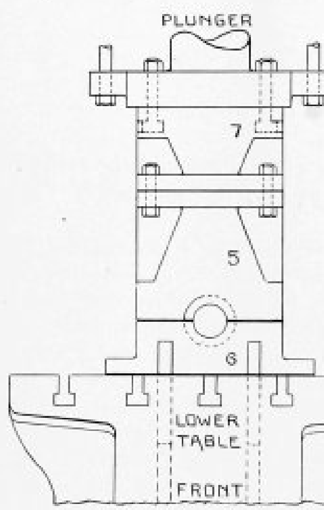


FIG. 2.

The operation of this die is as follows:

The vertical rams are raised just enough to permit the end of the heated stay rod to be placed between them. Then the pressure is applied and the top and bottom halves are brought tight together. This action holds the stay rod firmly in position. The pressure is then applied to the horizontal cylinder, and the horizontal ram is forced forward, upsetting the end of the stay rod into the die to the desired diameter.

The upsetting dies for a machine of this type are much more simple and easy to construct than those required to do the same work on a four-column press, as will be seen by comparison with the ones here shown and those about to be described. In this die no sliding block is necessary; neither is the wedge nor the back support used. This reduces the cost of such a die very materially when compared with the cost of that of a four-column press.

The most economical method of heating stay-rod ends is by the use of an oil furnace. These furnaces are arranged with several openings. They can be used for either welding tubes or heating the ends of stay rods.

The combination of these dies, together with the sectional flanging machine and the oil furnace, makes a fine outfit, and one upon which much work can be accomplished.

A great many shops throughout the country, however, are equipped with the four column press instead of the sectional flanging machine, and as the four-column type is not regularly equipped with a horizontal ram, which is used to such good purpose in doing this work on the sectional machine, the problem is a perplexing one. One of our engineers recently designed the dies shown in the illustration and described below for upsetting the long-threaded ends of large stay rods such as are used in the continental, marine and stationary boilers and similar types.

A similar set of dies was designed some years ago by Mr. H. L. Wratten, of Racine, Wis. The dies designed by Mr. Wratten, however, have a taper on both sides of the wedge. This necessitates the arrangement of the top part of the wedge so that it will slide back and forth while the dies shown herewith can be bolted substantially to the end of the plunger and do not need any arrangement for lateral movement.

With these dies the length of the upset part of the stay end is limited only by the length of the stroke of the plunger in the upper head, and the taper on the die blocks.

Fig. 5 represents a side view of the upsetting die, showing

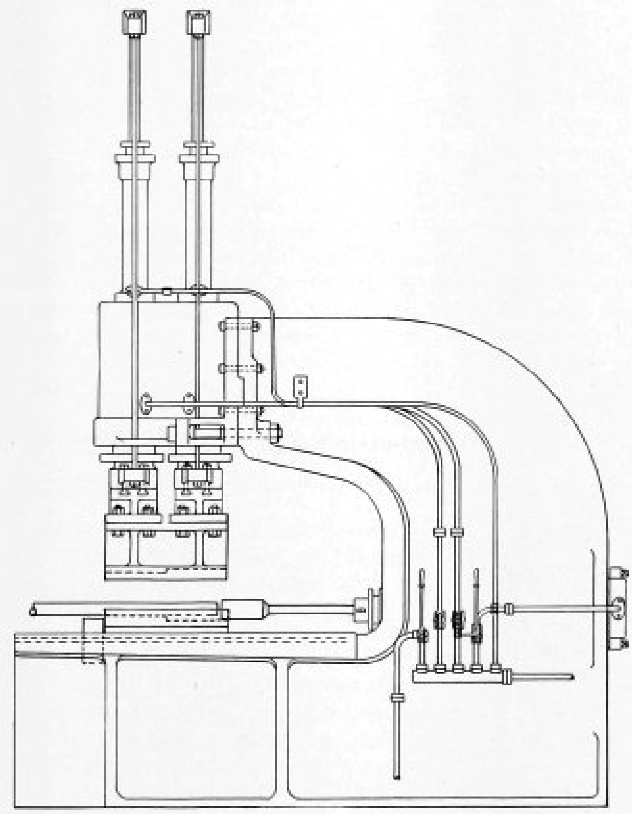


FIG. 3.

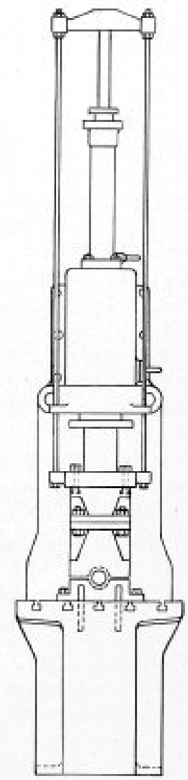


FIG. 4.

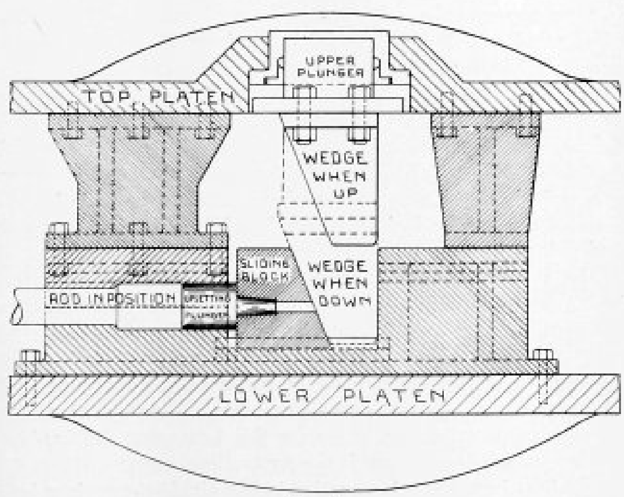


FIG. 5.

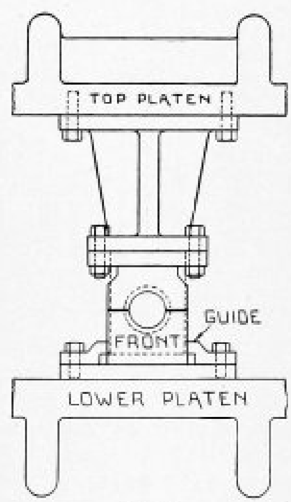


FIG. 6.

a rod in position after being upset, and shows the manner in which the machine accomplishes its work.

Fig. 6 is a view looking at the front end of the die. It will be noticed that the lower part of the die is divided into two halves, the opening between them receiving the stay rod.

The dies are operated in the following manner: First set the dies, then release the pressure and allow the upper wedge piece to ascend and the lower platen to descend, carrying with it the lower portion of the die. The lower platen need only be lowered about 2 inches, or just enough to open the dies far enough to allow the hot end of the stay to be placed in the rod opening. The length of the rod necessary to make the upset end is now calculated, and the lower wedge shape or sliding block, which holds the upsetting plunger, is set back to a gage far enough to allow the hot rod to be placed into the die to make the upset end. When the hot rod is placed in position the pressure is applied and the top and bottom dies brought together, thereby holding the stay rod fast between them. The pressure is then applied to the top plunger and the wedge-shape die descends, forcing the sliding block forward; this carries with it the upsetting plunger that upsets the heated end to the desired diameter, which is, of course, regulated by the diameter of the opening in which the plunger travels.

Such dies as these are usually made large enough to upset the largest stays, and when smaller sizes are to be upset, bushings made of soft steel and cut in halves are used. These bushings can be held in place by a key or by a flat-head screw.

For the convenience of those who have occasional use for information pertaining to the use of upset stay rod ends, we

STAY RODS WITH UPSET ENDS FOR CONTINENTAL, MARINE AND OTHER BOILERS.

Diam. of Rod Before Upsetting.	Area of Rod Before Upsetting.	Diam. of Upset End.	Area of Upset End.	Length of Upset End.	Number Threads Per Inch.	Additional Length Req. for Each End.	Nearest Fraction.	Diam. of Washer.	Thickness of Washer.
1 1/8"	.9940	1 3/8"	1.4848	3 1/2"	6	1.797	1 51/64	None	Tapped in Heads
1 1/4	1.2271	1 1/2	1.7671	3 3/4	6	1.716	1 23/32	"	
1 3/8	1.4848	1 5/8	2.0739	4	5 1/2	1.6304	1 41/64	"	None
1 1/2	1.7671	1 3/4	2.4052	4 1/4	5	1.5953	1 19/32	"	"
1 5/8	2.0739	1 7/8	2.7611	4 1/2	5	1.545	1 35/64	7 1/2	1/2
1 3/4	2.4052	2 1/8	3.5465	4 3/4	4 1/2	2.343	2 11/32	7 1/2	1/2
1 7/8	2.7611	2 1/4	3.9760	5	4 1/2	2.288	2 19/64	7 1/2	1/2
2	3.1416	2 3/8	4.4302	5 1/2	4	2.345	2 11/32	8	1/2
2 1/8	3.5465	2 1/2	4.9087	5 3/4	4	2.296	2 19/64	8	1/2
2 1/4	3.9760	2 5/8	5.4119	6	4	2.25	2 1/4	8	1/2
2 3/8	4.4302	2 3/4	5.9395	6 1/4	4	2.214	2 7/32	8	1/2
2 1/2	4.9087	2 7/8	6.4918	6 1/2	4	2.1798	2 11/64	8	1/2
2 3/4	5.9395	3 1/4	8.2957	6 3/4	3 1/2	2.7840	2 25/32	8	1/2
3	7.0686	3 1/2	9.6211	7	3 1/2	2.628	2 5/8	8	1/2

The above table gives the amount of material required to form the upset end. Four percent has been added to the actual length required for waste in heating, to make fillet and to take care of roughness, etc. Full nut outside and split nut inside where washers are used.

publish, herewith, a table containing much information useful to those interested in the subject. This table is prepared for bolts 1⅝ inch in diameter and larger, having upset ends with washer and one nut outside, and for a split nut on the inside. Bolts up to and including 1¼ inches are threaded in both sheets with nut on outside only. Bolts 1⅜ inches in diameter up to and including 1½ inches have nuts on outside and split nuts on inside, but the washer is omitted.

In order to calculate the extra length required for making the upset end, proceed as follows: For illustration, we will take a 2¼-inch stay rod having an upset end 2⅝ inches in diameter and 6 inches long.

We would first obtain the area of 2¼ inches diameter, which is 3.9760. Multiply this by 6 inches (which is the length of the upset end) = 23.8560, number of cubic inches in a bar 2¼ inches in diameter and 6 inches in length.

Next find the area of 2⅝ inches diameter (which is 5.4119), and multiply this by 6 inches (the length of the upset part) = 32.4714 cubic inches. Then subtract the cubical contents of the small diameter from the larger. The remainder will be the number of cubic inches of material required to make the upset end. Then 32.4714 — 23.856 = 8.6154. Divide this by 3.9760 (which is the area of 2¼ inches diameter) = 2.166 inches, this being the actual additional length required to make the upset end, provided none of the material was wasted in the fire by being brought to a welding or wash heat, and it was possible to upset the material so that it would be perfectly smooth, as well as to prevent it from squeezing into the parting of the dies; but since it is practically impossible to prevent a little waste of material, it is necessary to allow a small percentage to the length of rod found by calculation. This extra allowance necessary has been found to be about four percent of the net extra length required: 4 percent of 2.166 = .08664. This, added to 2.166 = 2.25 inches additional length required on each end of a 2¼-inch stay rod having a 2⅝-inch diameter of upset end and a length of 6 inches. See table.—*Ryerson's Monthly Journal.*

Combustion and Heat Balances in Locomotives.*

BY LAWFORD H. FRY.

With any boiler it is important to know not merely the efficiency of the boiler but the nature and amount of the various heat losses which occur, and the effect which the design of the boiler has upon its efficiency and upon these heat losses under working conditions. In the following paper the author discusses these points in so far as the opinion gained from certain trials of locomotive engines furnishes data on which to pass such conclusions.

The tests were made on four different types of locomotives at the locomotive testing plant of the Pennsylvania Railroad. The illustrations show the details of the boilers of these locomotives. Fig. 1 is a single-expansion consolidation-type locomotive, No. 1,499, of the Pennsylvania Railroad. Fig. 2 is a single-expansion consolidation-type locomotive, No. 734, of the Lake Shore & Michigan Southern Railway. Fig. 3 is a Vauclain four-cylinder balanced compound Atlantic-type locomotive, No. 535, of the Atchison, Topeka & Santa Fe Railroad. Fig. 4 is a Cole four-cylinder balanced compound Atlantic-type locomotive, No. 3,000, of the New York Central & Hudson River Railroad. It will be seen that one of these boilers had a narrow fire-box and the other three wide boxes. Two of the boilers had no firebrick, while the other two had firebrick arches carried on water tubes.

The results of these experiments seem to show that the boiler efficiency is independent of the grate area; that is, that the same results are obtained by burning 72 pounds of coal per square foot of grate area per hour on a grate containing 55.5 square feet of surface, as by burning 134 pounds of coal per square foot of grate area per hour on 29.76 square feet of grate area, the reason given for this being that the fire-box volume, which is constant, is the controlling factor.

The heat losses in a locomotive boiler divide themselves into three main groups:

1. Loss of heat in the products of combustion.
2. Loss of heat by external radiation.
3. Loss of heat by imperfect combustion.

These three losses, together with the heat usefully employed in the production of steam, must account for all of the heat contained in the coal and complete the heat balance.

(1) *Loss of Heat in the Products of Combustion.*—The products of combustion consist of certain dry gases, as shown by the analyses of the flue gases, and in addition to these a

*From a paper presented before the British Institution of Mechanical Engineers.

considerable amount of water vapor from the water of combustion of the hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. The water of combustion with the sulphuric acid amounted to 0.40 pound per pound of coal burned. The moisture in the coal was always in the neighborhood of 1 percent and therefore the water vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 pound. This comprises the water of combustion and the moisture in the coal as fired. In addition

analysis of the flue gases. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in one instance there is no very serious loss on this score. One individual test shows a loss of 16.33 percent by CO. This is due to the rapidity with which the air-supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler and prevented the rate of combustion being pushed above 90 pounds of coal per square foot per hour.

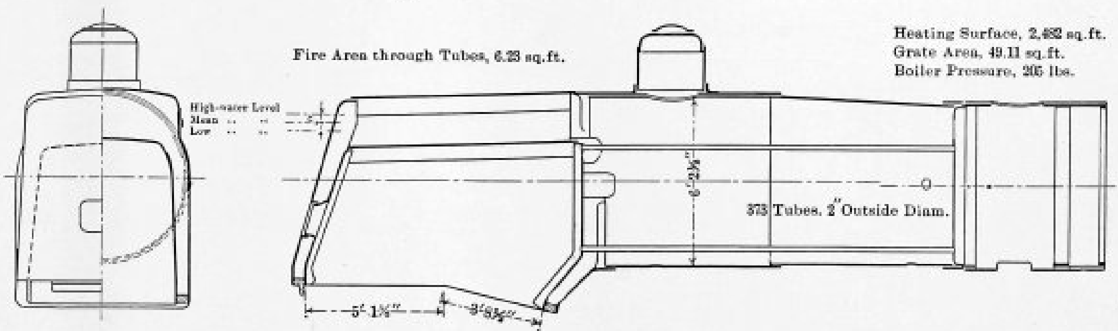


FIG. 1.—BOILER OF SINGLE-EXPANSION CONSOLIDATION-TYPE LOCOMOTIVE, PENNSYLVANIA R. R.

to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air varies from 0.48 to 1.25. The weight of the dry, gaseous products of combustion per pound of coal burned is 0.54 pound more than the weight of air supplied per pound of coal.

The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned, on the temperature at which they escape to the smoke-box, and on the specific heat

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:

(*a*) Partially unconsumed as sparks.
(*b*) Partially unconsumed in the ashpan.
(*c*) As unconsumed gas in the products of combustion. This last entails a secondary loss by
(*d*) The sensible heat of the unconsumed gas in the smoke-box.

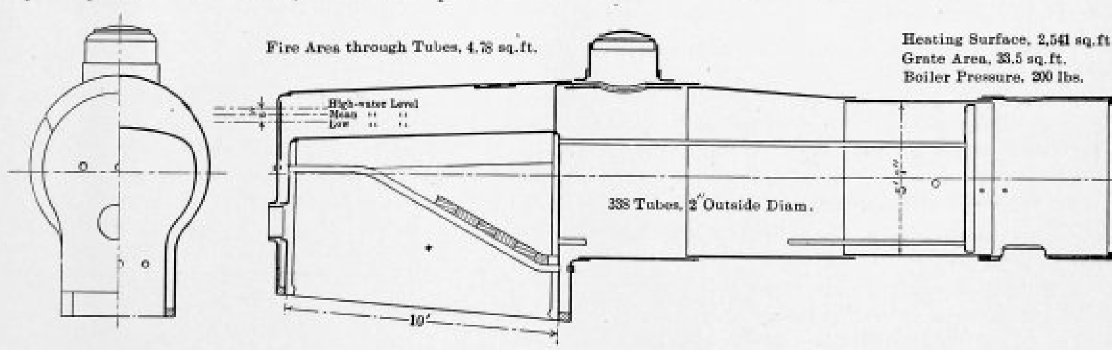


FIG. 2.—BOILER OF SINGLE-EXPANSION CONSOLIDATION-TYPE LOCOMOTIVE, LAKE SHORE & MICHIGAN SOUTHERN RY.

of these substances. Although there is some evidence to show that the values of these specific heats vary with the temperature, the large majority of heat balances hitherto calculated have assumed constant specific heat values of 0.24 for the dry gases and 0.48 for the superheated water vapor.

(2) *Loss of Heat by External Radiation.*—This loss was not measured, and, as the loss by unburnt coal was not measured, the radiation loss cannot be determined by difference. It seems, however, permissible to assume that the loss by external radiation is 5 percent of the heat utilized by the boiler in evaporation. This cannot introduce any essential error, and it harmonizes with the little that has been published on this subject.

(3) *Loss by Imperfect Combustion.*—This falls under two heads:

(i) Loss by production of carbon-monoxide.
(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first-mentioned loss can be calculated from the

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by the method which is described below, and which is illustrated by the following example:

In one test there is known	Percent.
Heat of evaporation	47.20
Heat lost by external radiation	2.36
Heat lost in production of CO	0.70
	50.26
This leaves the loss to be divided between the products of combustion and unburnt coal.	49.74
	100.00

The heat lost in this test in the products of combustion is 19.30 percent of the total heat of the coal *actually burned*. Now, if, for example, 25 percent of the coal were to escape unburnt, the loss in the products of combustion would apply only on the remaining 75 percent actually burned, and would be 0.75×19.3, or 14.5 percent of the heat of all the coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is

$$\left(\frac{100 - P}{100}\right) 19.3$$

percent of the total coal *fired*, or calling this P_1 we have

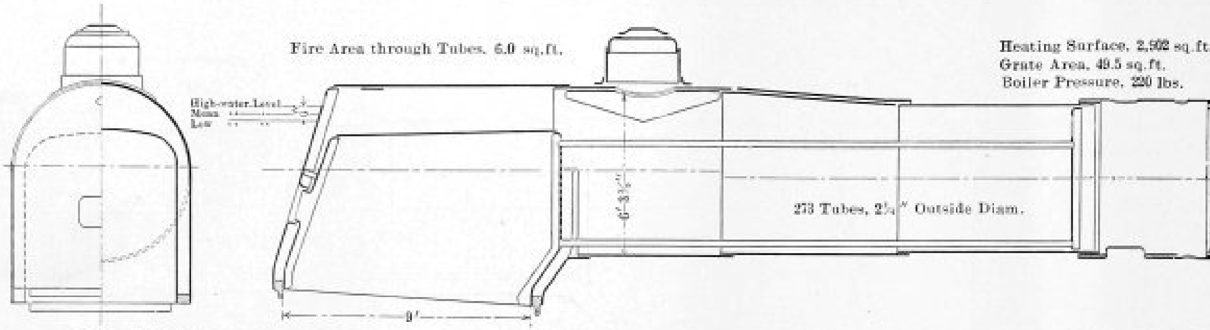


FIG. 3.—BOILER OF VAUCLAIN FOUR-CYLINDER BALANCED COMPOUND ATLANTIC-TYPE LOCOMOTIVE, ATCHISON, TOPEKA & SANTA FE R. R.

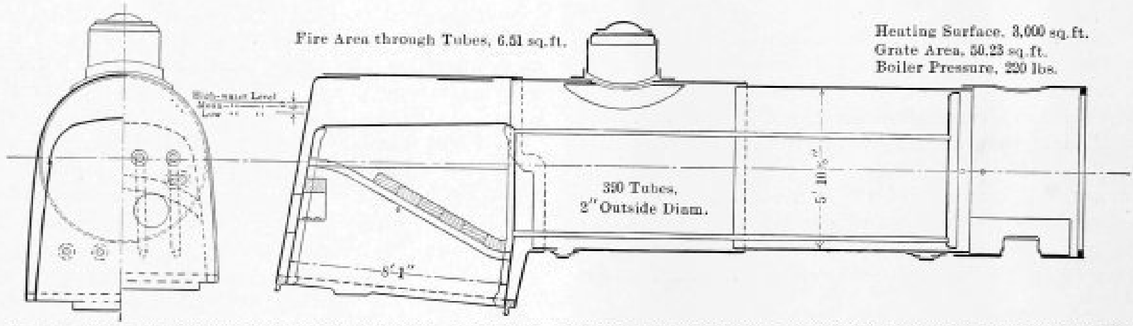


FIG. 4.—BOILER OF COLE FOUR-CYLINDER BALANCED COMPOUND ATLANTIC-TYPE LOCOMOTIVE, NEW YORK CENTRAL & HUDSON RIVER R. R.

$$P_1 = \left(\frac{100 - P}{100}\right) 19.3,$$

and

$$P_1 + P = 49.74,$$

whence, by simple algebra, it is found that P, the loss by unburnt coal, is 37.70 percent.

It appears that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating surface absorbs about 81 percent of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the total heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing is increased from 30 to 130 pounds per square foot of grate, the weight of the products of combustion is reduced from about 18 pounds to about 8.5 pounds per pound of coal fired. For complete combustion about 11 pounds of air are required, so that when the boiler is forced it is not possible to get enough air through the fire to burn all of the coal fired.

In examining the effect of the variation of grate area three series of tests were run: (1) with the full grate area of 55.5 square feet; (2) with the front of the grate covered with firebrick, so that the effective grate area was reduced to 39.5 square feet, the ratio of grate area to heating surface being 1 to 58.7; (3) with the effective grate area still further reduced to 29.76 square feet, giving a ratio of grate area to heating surface of 1 to 77.9. The results of these runs showed that at any given rate of evaporation there is very little difference between the efficiencies of the three series. Also at the lower rates of evaporation the largest grate gives the lowest efficiency and the smallest grate the highest efficiency; while at the high rates of evaporation the reverse is the case, the largest grate giving the highest efficiency. This is due to the fact that the resistance to the passage of the air through the grate is least with the large grate and greatest with the small grate. At low rates of combustion the most important losses are those due to an excess of air; consequently the large grate has the lowest efficiency. At the high rates of combustion the most important losses are those due to coal escaping unburnt from a lack of sufficient air for proper combustion, and hence the largest grate, by admitting the air most freely, gives the highest efficiency.

Fuel oil is to be substituted for coal wherever practicable at stationary boiler plants along the Panama Canal. The Union Oil Company of California has an 8-inch pipe line across the Isthmus, practically parallel with the Panama Railroad, and a contract has been made between it and the Canal Commission, under which the company is to furnish crude oil at any convenient point along this line at the rate of 90 cents a barrel. It is proposed to take 4-inch branches from the main and run them to large tanks placed some distance above the boilers of the plants in which the oil will be used. These tanks will hold approximately one month's supply. The oil will be fed by gravity to the burners of the steam-jet type attached to the furnaces, and an attempt will be made to heat the air under the boilers before it comes into contact with the oil. Oil has been used at the La Boca electric light plant for some time, where \$2.70 worth of oil does the work of \$6.35 worth of coal.

Altering Locomotive Fire-Boxes to Secure Increased Efficiency.

BY ALFRED COOPER.

A few months ago a number of new engines were placed in service on the St. Joseph & Grand Island Railroad. These engines were of the type shown in the photograph, Fig. 1, and were operated at a working steam pressure of 210 pounds per square inch. Each engine contained 331 flues 2 inches in diameter by 14 feet long. After a few months' service it was found necessary to patch the side sheets and the top flange of the flue sheet. In order to reduce the number of such repairs to the fire-boxes, their design was changed by Mr. F. T. Slayton, master mechanic of the road, to give increased water space around the side sheets. As shown in the photograph, Fig. 2, the side sheets were curved inwards to give about 2½ inches more water space. Also seventy-five flues were taken out and the bridges increased to 1 inch. This gave more water space around the flues. The diaphragm sheets were perforated with 3/16-inch holes; which was found to regulate the draft better and give better results on the top rows of flues.

These new fire-boxes have now been in service about twenty-four months and are giving no trouble whatever. They steam perfectly, and their tonnage is just the same with 256 flues as it was with 331 flues. Furthermore, the flues are now always open, whereas formerly about one-half of them were stopped up.

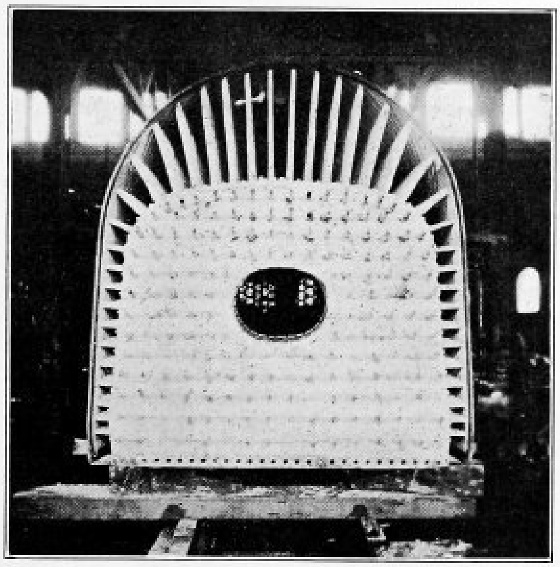


FIG. 1.

Relation of Government Fuel Investigation to the Solution of the Smoke Problem.*

BY D. T. RANDALL.

Statistics collected by the government indicate that the nation has consumed about seven billion tons of coal up to the present time. Last year the consumption was more than four hundred million tons. During the past ten years nearly as much coal was used as had been used during the preceding century. This increase in the use of coal during the past century has been so great that it is concluded that if the consumption continues to increase at the same rate, the coal fields of this country will be exhausted before the end of the next century. However, if by some means the increase in the use of coal can be checked and the output of the mines kept down to the present figures, there will be no occasion to worry about the coal supply. But the increased demand for coal will probably continue, and we may reasonably look for a gradual rise in the price of coal as it becomes more difficult to mine it. Only the best and most profitable seams are being mined at the present time, the inferior coal being left in the ground.

As used at present for heat, light and power, the losses are so great that, of the total heating value of the coal, less than 5 percent is converted into useful work in the ordinary manufacturing plant, and even some of the largest and best power plants are able to utilize only about 10 percent of the energy in the coal. In railroad operation only from 3 to 5 percent

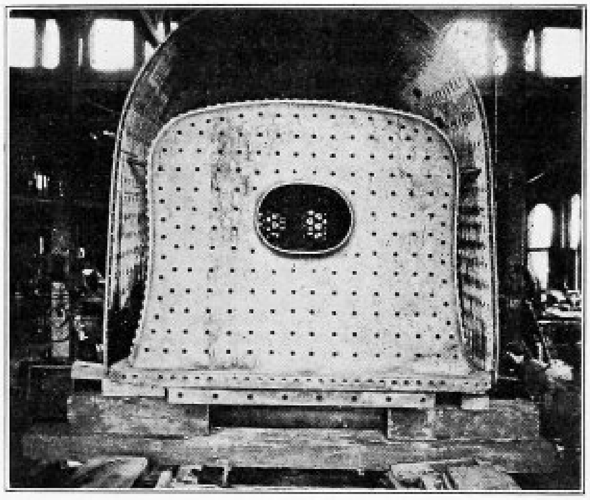


FIG. 2.

of the coal value is realized for pulling the train. It is estimated that only one-seventh of 1 percent of the fuel value is actually converted into light in an incandescent lamp. Nearly two million horsepower in the form of gas is allowed to escape from the blast furnaces of the country. This condition is rapidly being changed by the installation of gas engines to develop the power. There is also a great fuel waste in the manufacture of coke, besides the loss of many valuable by-products. It is estimated that these losses amount to fifty million dollars annually.

Believing that the present wasteful methods of utilizing our fuels can not long continue without serious harm to our country, men prominent in the affairs of the government, engineers, manufacturers and others have pointed out the necessity of studying the fuels and the methods of utilizing them with the best economy. This has been entrusted to the fuel-testing division of the technologic branch. It is a matter that covers a wide scope and requires much experimental work extending over a considerable period of time. It was begun at St. Louis during the Exposition in 1904, by the United States Geological Survey, and has since been continued at St. Louis and Norfolk.

The possible benefits to the government and to the public resulting from such experiments led the President to appoint a number of prominent engineers, some in the employ of the government and some as members of the great national engineering societies, to act as an advisory board on fuel and structural materials investigations. Among the organizations represented are:

The War Department; the Navy Department; the Treasury Department; the Reclamation Service; the Isthmian Canal Commission; the American Institute of Mining Engineers; the American Institute of Electrical Engineers; the American Society of Civil Engineers; the American Society of Mechanical Engineers; the American Institute of Architects, and

* Address delivered before the annual convention of Smoke Inspectors, at Cleveland, Ohio, June 24, 1908.

all other leading engineering societies. The board meets occasionally to discuss the nature of the experiments which are most needed and in a general way the means of conducting them. The experimental work is done under the direction of the chief of the technologic branch, the details being settled after consultation with engineers who are experts in the particular lines being investigated. A regular force of engineers, chemists and computers carries on the tests as planned and prepares the results for publication.

The purposes of the fuel investigations now in progress are as follows: To lessen the waste in the nation's fuel supply. To determine the amount, quality, properties and most efficient methods of utilizing the fuels belonging to the United States, occupying some fifty million acres. The analyzing and testing of coals, using carefully-collected samples typical of the various coal fields in the United States, with a view to assembling of data which will serve as a basis of information needed both for the purposes of the government and those of the general public. To determine means whereby low-grade fuels, bone coal, culm slack, washery refuse, lignites and peats, heretofore practically unused, may be made of commercial value. The abatement of smoke, with the resulting increased efficiency when burning coal, with all kinds of equipment.

The importance of making investigations to secure economy can be better appreciated when we consider the cost of fuel delivered to the furnaces, including all items, such as the cost at mines, freight, cartage, handling and firing at the plant, on locomotives, steamships, etc. This figure has been placed at nearly two billion dollars annually for all the coal used in this country. A saving of only 1 percent on the entire fuel bill of the country would amount to nearly twenty million dollars annually.

A study of the fuel values of coals burned while conducting some 540 boiler tests has shown that the value of the coal depends almost entirely on the number of heat units which it contains as determined by a calorimeter, these relative values being influenced somewhat by the amount and character of volatile matter and of ash present in the coal. This information has strengthened the position of the government engineers who desire to purchase coal on a specification which has for its basis of payment the British thermal units and ash in the coal. For the coming year a very large part of the coal purchased for the government will be paid for according to its value as determined in the government chemical laboratories. One of the largest purchases under this form of contract is for use on the Isthmus of Panama and calls for the delivery of four hundred thousand tons within the year.

Investigations of the washing and coking tests of coals have also shown the possibilities of utilizing poorer grades of coal than are commonly used, and point to a very considerable saving in our fuel supply. The experiments on the briquetting of coal have shown that the slack coal, which is otherwise difficult to utilize, may be made into artificial lumps and used with high efficiency in power plants or for locomotive use.

A study of the furnace conditions in connection with the boiler tests will show the influence of different methods of burning coal with relation to the reduction of smoke. These tests have demonstrated the possibility of burning certain kinds of coal efficiently without smoke in an ordinary furnace. They have pointed to possibilities of modifying furnaces so that practically all fuels may be burned without smoke under favorable conditions. Some bulletins have already been issued on this work, but those which deal directly with the smoke problem are now in course of preparation. The tests made at the producer-gas plant have shown that it is possible to burn almost any grade of coal with the very highest efficiency and absolutely without smoke. Bituminous coals having as high as 45 percent of ash, lignites and peats, which are considered low grades of fuel for boiler furnaces, have been very successfully burned in the producer, generating gas for the development of power in a gas engine. The low-grade lignites of North Dakota developed as much power per pound in the gas producer as do the very best West Virginia bituminous coals when utilized in a steam boiler with a simple non-condensing engine.

The results of these investigations will have an important bearing on the question of smoke prevention, both directly and indirectly, but the government is investigating the possibilities only from the engineering and not at all from the legal standpoint.

Layout of a Spout Intersecting a Conical Body.

BY F. WEBSTER BRADY.

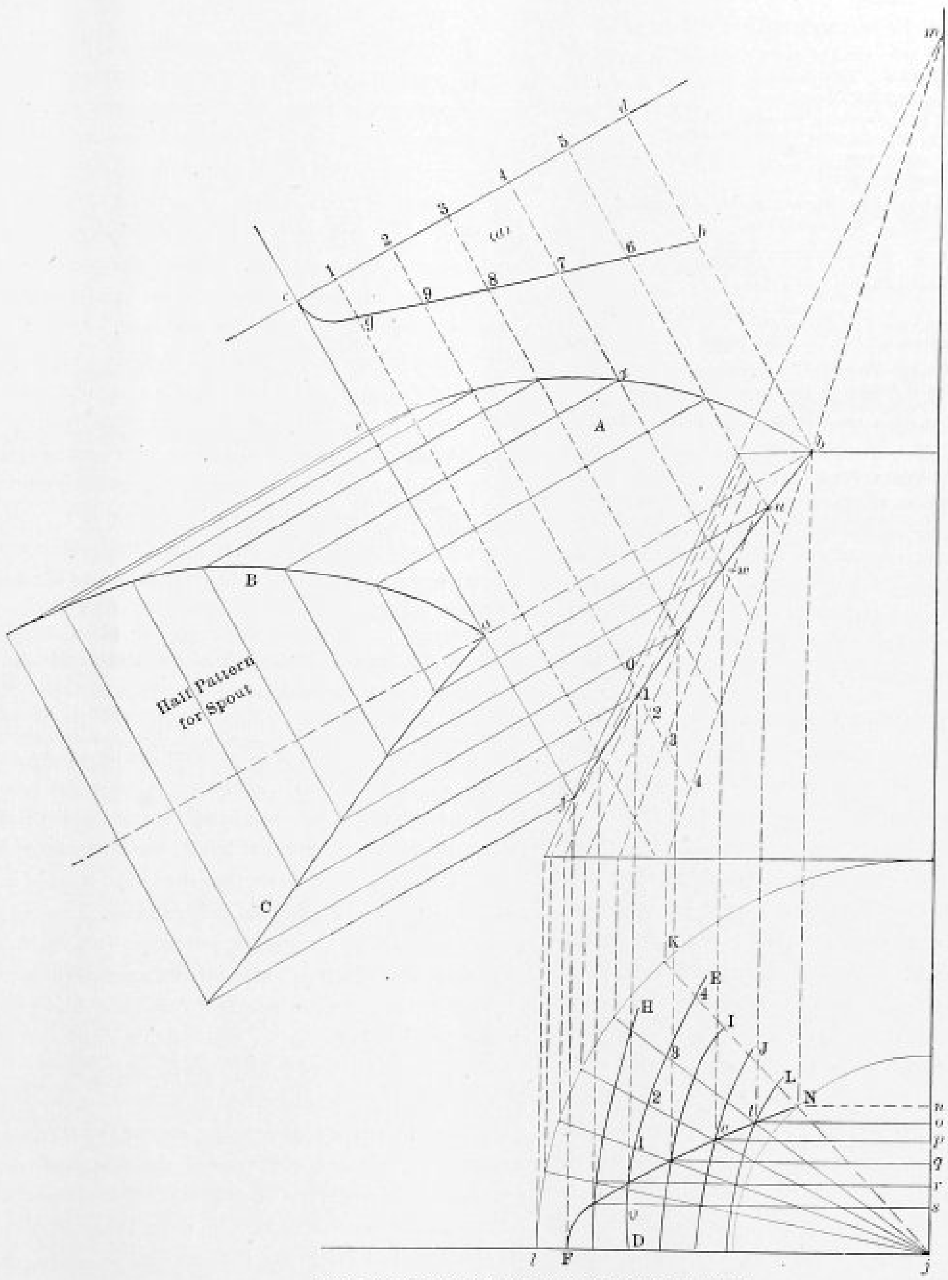
There is a certain class of patterns that is always troublesome to the sheet metal workers. This is owing to the fact that the curves formed by the intersection of some kinds of surfaces cannot be laid out except by making several intermediate constructions that are not required in ordinary work. A good example showing the extra work necessary to make the pattern is the layout of a spout intersecting a conical body. As the same principle is used in other important constructions, the following illustration and description of the work will make clear the parts that cause the pattern maker the most trouble. The difficult part of this problem is to find the curve on the pattern of the spout that is to fit the body. This curve is found first in the projection of the plan, and from this the projection in the elevation is made, and finally the curve on the pattern is made from the elevation. It is advisable in a case of this kind to make an actual layout of the pattern from the beginning, performing each step in the process, and also to make the drawing to a large scale, so that the different projections will not become confused.

In the sketch, the first thing that is made is the plan, and the elevation of the frustum of the cone used for the body. Also, in the elevation, the side view and the section of the spout are made to any desired size and form. The side view of the spout is shown at *A*, and a section of the spout along the line *ab* is shown at (*a*). In making the section at (*a*), draw a line *cd* at right angles to the edge of the spout, and at the point *c* draw an arc of a circle of any desired size. Then draw a tangent *gh* to this arc, making the width *dh* the same as the half width of the spout at *b*, or equal to *jn* as shown in the plan. The angle of the spout is usually 45 degrees, and is laid out at *F j K* in the plan.

The curve for the top of the pattern is very easily made, and is shown at *B*. In order to get this curve, divide the line *c d* into any number of parts desired, and draw lines parallel with the edge of the spout *e f*. Where these lines cut the curve *e x b* of the top of the spout, draw lines parallel to *c d* to the left an indefinite distance. From the point *a* to the left, lay off distances equal to the sections *h*-6, 6-7, 7-8, etc., along the edge of the spout as shown at (*a*) and erect perpendiculars at these points to intersect the horizontal lines previously drawn. These intersections will give the points in the curve *B* for the top of the pattern of the spout.

To get the curve *C* for the bottom of the pattern where the spout joins the body is more difficult, as two or three intermediate steps must be taken. In the first place, divide the arc *l K*, shown in the plan, which includes the width of one-half the spout, into any number of equal divisions, and draw radial lines from the center *j* to each of these. Also, draw the projections of these lines in the elevation through the vertex *m* of the cone. Five divisions are made in the drawing. The next thing to do is to get the horizontal projections of a series of curves that are cut from the cone by the several planes passing through the line *cd*. Thus, the plane through the point 2 on *c d* crosses the several lines drawn on the cone through the vertex *m* at the points *O*, 1, 2, 3 and 4. By projecting these points down to the plan on the corresponding lines of the cone, we get the points *O*, 1, 2, 3 and 4. Then draw the curve *D E* through these points. This curve is not a circle, but is of irregular form and may be laid out by the use of a special curve that will pass through the points. In the same manner the several other curves *H*, *I*, *J* and *L* are obtained in the plan by the use of the lines through the other points on the line *c d*. After getting these irregular curves on the plan, the next step is to lay out the distances on the vertical line *j n*, making *j n* equal in length to the line *d h* of (*a*). Then make the other heights *j o*, *j p*, *jq*, etc., equal in length to the lines 5-6, 4-7, 3-8, etc., of (*a*). Draw horizontal lines through the points on *j n* intersecting the different irregular curves on the plan. The irregular curves show the form of the spout at the section where the respective planes were passed, and the distances on *j n* give the width of the spout at each of these locations, so the points of intersection of these horizontal lines and the irregular curves are points on the horizontal projection of the curve where the spout unites with the body. This curve has been drawn through the points and is shown at *F N*.

The next step is to get the vertical projection of this curve on the body. This is done by drawing vertical lines through the points that determine the curve in the plan to the corresponding lines in the elevation drawn from the line *c d* in (*a*). Thus, the point *t* in the plan is projected to the point *u* in the elevation; the point *v* in the plan to the point *w* in the elevation, etc. After getting the several points in the elevation, the vertical projection of the curve where the spout unites with the body is drawn as shown at *f b*. Next, through the several points *u*, *w*, etc., on the vertical projection of this curve, draw lines parallel to the line *a b*, extending them indefinitely to the left across the ordinates on the pattern already drawn for the curve *B*. The points obtained by the intersection of these lines, with the ordinates of the pattern, will locate the curve *C* for the lower edge of the pattern.



PLAN, ELEVATION AND PATTERN OF TAPERING SPOUT.

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.

The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

The Stay-Bolt Question.

In considering the stay-bolt question it should be remembered that the life of a stay-bolt depends very much upon the condition of the taps and dies used, and also upon the shape of the threads. A stay-bolt cut with a sharp-edged die will bend a good many more times without breaking than one which is cut with a dull die. Dull dies indent the soft iron, leaving the bolt in such a condition that cracks are easily started by repeated bending. It is to prevent the formation of just such cracks that stay-bolt iron is so carefully piled during its manufacture, and, of course, any subsequent treatment which tends to start cracks, such as the use of dull dies, should not be tolerated. There is another thing which has an important effect upon the life and breakage of stay-bolts, and that is the tightness of the bolt in the outside sheet. Loose stay-bolts seldom break; whereas, if a bolt fits tightly in the outside sheet the comparatively hard steel of the boiler plate will indent the soft iron of the bolt, so that repeated bending will tend to start cracks. By making the bolt a rather loose fit in the sheet and carefully heading it over to prevent leakage, the bolt will be able to work slightly in the sheet, and thus reduce the bending stresses in it. The action of a bolt fitted in this way is, of course, somewhat similar to the action of a flexible stay-bolt. Since the necessary tightness can be obtained by carefully heading the bolt outside the sheet, it is not necessary that it should fit in the sheet at the bottom of the threads. Therefore, rounded threads can be used, and sharp threads, which tend to cut into the iron, can be done away with. Any bolt which is fitted slightly loose in the sheet is, of course, liable to become tight after it has been in service a short time. A deposit of hard scale can find its way into any space there may be between the bolt and the sheet, holding the bolt rigidly.

In foreign countries, where copper fire-boxes are used to a greater extent than they are in this country, it has been customary to use copper stay-bolts. These gave fairly good satisfaction when steam pressures did not run higher than 150 pounds per square inch, but when steam pressures of 200 pounds per square inch and over came into use, the breakage of copper stay-bolts was very troublesome. Various types of bolts were tried, but as they only partially solved the problem different materials were experimented with. Iron was first tried, then soft steel, and finally nickel steel, but stay-bolt breakage was not decreased. Finally the problem was solved by the use of manganese bronze, a material which consists of copper with 3 or 4 percent of manganese. After a number of years' trial it has been found that when manganese bronze stay-bolts are used stay-bolt breakage is decreased about 90 percent, so that nearly all high-pressure boilers in which copper fire-boxes are used are fitted with bronze stay-bolts.

The stay-bolt question is one of the most important which confronts boiler makers to-day, and no point is too small to be overlooked where there is an opportunity both for a saving in expense and for giving additional safety to the boilers.

Smoke Prevention on Railroads.

At the recent convention of the International Association for the Prevention of Smoke, Inspector Bird, of Chicago, stated that the great trouble in eliminating smoke on the railroads, is that the officials of the roads allow the boiler makers to decide what is to be done in this matter instead of ordering them to carry out ideas that have been formulated by others. It has always seemed to us that the great trouble in eliminating smoke on railroads is the expense. Smoke could be greatly reduced by burning a smokeless fuel, such as anthracite, coke or briquettes, but few roads are willing to use such expensive fuel, except perhaps for their highest-class passenger service, both on account of the high cost of the fuel itself and on account of the expense which would be incurred in adapting their locomotives to the use of such fuel. The next best means of preventing smoke on railroads is the employment of carefully trained firemen, and that, too, is expensive, although the saving in coal consumption which a good fireman can effect ought to more than offset any expense involved in educating the fireman and in paying him higher wages. The third possible way of solving the smoke problem is by changing the furnace conditions in the boiler to secure better combustion of low-grade fuel. This method involves the use of such devices as mechanical stokers, down-draft furnaces, firebrick arches, steam jets, etc., and it is only natural that railroad officials should depend upon the boiler makers for information regarding the availability of such devices, for even though a device of this kind may give promise of doing wonders for the smoke problem it may also tend to increase boiler failure and consequently increase the expense of repairs. Cost is the first consideration in railroad work.

TECHNICAL PUBLICATIONS.

Heat and Light from Municipal and Other Waste. By Joseph G. Branch. Size, 5¼ by 7¾ inches. Pages, 305 Illustrations, 53. Rand, McNally & Company, Chicago. Price, $3.00.

In this book the author points out the fact that in nearly all large cities in the United States the cost of refuse disposal is very much higher than it is in foreign cities, the average here being about 28 cents per capita, while in any foreign city it rarely exceeds 1 cent per capita. This is said to be due to the fact that all refuse in foreign cities is incinerated, and the waste heat therefrom utilized for some public works, such as electric lines, water works, sewerage pumping, etc. One of the main objects of the book is to present a vast amount of data collected by the author, to show the economy which might be obtained from the use of modern central heating plants to supply heat for large districts, the fuel for these plants being the city waste. The chief interest of the book for boiler makers lies in the fact that the proper design of a furnace to utilize city waste is considered as well as the adaptability of various types of boilers for use in this connection.

Proceedings of the Western Railway Club. Size, 6 by 9 inches. Pages, 352. Illustrated. Published by the Western Railway Club, Chicago.

The proceedings of the Western Railway Club for the year 1907-1908 have been conveniently edited in the shape of a cloth-bound volume including all the papers presented before the society during the year, as well as reports of various committees, constitution and by-laws, list of members, etc. The papers cover such subjects as broken tires, breakage of wheel flanges, effect of brake-shoe friction on wheels, freight car efficiency, car lighting, relation of car wheel to rails, heating and ventilating of passenger cars, cast-iron versus steel wheels, characteristics of structural timber, influence of heat value on railway fuel cost, education of young men entering mechanical pursuits, and coning of car wheels, treads and rails. The full discussion of these papers, which took place at the meetings of the society, is also given.

COMMUNICATIONS.

The Effect of Not Laying Up in Riveting.

Editor The Boiler Maker:

In any kind of riveting, either hand or machine work, it pays to lay the work up good and tight. At the present time most riveting is done by machine, and you can usually get a good, tight job; for it stands to reason that a good hammer in the hands of a man who understands how to use it can drive the work up in shape a great deal quicker than in the old way by hand, as the air hammer strikes quicker and far heavier blows than can be struck by hand, and, as no time is lost between blows, the rivets are driven into place while hot. Many, when using an air hammer, keep twisting it from side to side or rolling it around the rivet. There is no cause whatever for this procedure, for with the proper cup in the hammer you get a better head and tighter rivet if you drive straight on to the rivet. If a sheet or a patch is to be riveted, get it in place with as little pinning as possible (little pinning will be required if the layer-out does his work carefully). Be sure that your rivets are the right length, then drive them down to the sheet and "lay her right home." Finally get back on the rivet and finish it up, making a tight job.

I have seen a patch put on a side sheet down near the mud ring, taking in four rivets on the ring. The patch was chipped and calked, and, when the test was put on, the rivets leaked a little in the ring. The man who tried to calk them succeeded in getting one tight, but the others were worse than ever. Then he drove one and laid it up where it ought to have been in the first place. The other one was still leaking badly and had to be cut out. The rivet was then driven with plenty of good laying up and then the job was tight.

Harry Jewell.

Be Sure that the Blow-off is Shut.

Editor The Boiler Maker:

An article in a recent issue of The Boiler Maker reminded me of an experience that I once had while inspecting boilers. I was to inspect one boiler in a battery of five. Three of the five boilers were under a steam pressure of about 90 pounds. The fourth was under a reduced pressure. While getting ready to inspect the boiler the engineer informed me that I could inspect another boiler on the next day, as it had only 20 pounds steam pressure on it. I consented to do this, and he told the fireman to blow it off. The blow-off pipe had an auxiliary valve at the end which was closed, while the blow-off valve to the boiler which I was to inspect was open. Therefore, when the fireman opened the valve of the boiler which was under 20 pounds pressure the hot water was blown into the boiler which I was about to enter. If I had been in the boiler at the time I should have been scalded to death. In view of this experience I would advise anyone who has occasion to enter a boiler which is connected with other boilers under pressure or with hot water in them to be sure that the blow-off is shut.

J. M. Jones.

How to Put on a Patch.

Editor The Boiler Maker:

In the first place, do not bother with any copper wire between the two plates. Put the patch on metal to metal. Assuming that a patch-bolt patch, 8¼ by 30 inches by 5/16 inch thick, is to be put on one of the side sheets of a locomotive boiler, first examine the old flaw, and with a rule measure accurately the size of the required patch; also mark off the part of the plate which is to be cut out on the old side sheet. Center-punch those lines and start your helper cutting off any stay-bolts that come in the patch. While he is doing this and cutting out the damaged part, get a piece of pasteboard paper, or some thick, stiff paper, and lay out the paper exactly as the new patch is to be laid out with every bolt hole in it. Use ¾-inch twelve-thread patch bolts spaced approximately 2 3/16 inches apart. The calking edge of the patch should be 1⅛ inches from the center of the patch-bolt holes.

Drill the holes in the old side sheet for the patch bolts 19/32 inch in diameter. Punch the holes in the new patch 13/16 inch diameter and countersink them so that the patch bolts will fit fairly down in the countersink. Be sure to put one hole in each corner of the new patch, making these four corner holes each ⅝ inch diameter. This is to prevent the bolted patch from springing or working when it is being calked.

When the paper templet is laid out, put it up on the old plate and carefully mark off all the holes for the patch. Center punch the holes carefully, and be sure that your helper drills them accurately. While these holes are being drilled take the paper templet and mark off the patch; shear and punch it, leaving the four ⅝-inch holes to be drilled. Countersink all the holes, then put the patch in a vise and chip it to a good bevel for a calking edge, rounding the four corners to a radius of about 1½ inches or 2 inches. Mark off whatever stay-bolt holes happen to come in the patch and put in the holes.

When everything is ready on the old plates clean off carefully any oil or burr and then put up the new patch. Whittle out three or four wooden plugs about 3 inches long and drive them into the patch-bolt holes, simply to hold up the patch. Now tap one hole in the middle and put in a bolt, then tap one under that and put in another bolt, screwing them up hard. Put in four or five more bolts on each side of those two, putting white lead on the bolts, screwing them up hard, hammering and turning them over and screwing up again. Now take out the two bolts which you put in first, cover them with white lead and put them back, setting them up hard. Tap the four ⅝-inch holes in the corners and put in ¾-inch bolts. Hammer up the plate well and set the bolts up hard, nicking their heads and twisting them off. Do this with all the bolts and hammer the heads over with the ball of a chipping hammer. Next take a hand flatter and flatten the heads up to the sheet; then take a fuller about ¾ inch wide and 3/16 inch thick and calk the heads into the sheet. Finish up the job with a rivet calking tool, catching the head of the bolt where the fuller left off, and calking the head right up to the plate. Be careful to cut the plate only a very little. As the patch has been chipped in a vise, run the flatter over the edge and then calk with a fuller, finally using a common square calking tool, ¾ inch wide and 3/16 or ¼ inch thick. A good scale will be left there, which must be cut off by means of a fine calking tool, ⅝ inch wide and 3/32 inch thick, ground to a sharp bevel.

HENRY MELLON.

PERSONAL.

P. S. MORRISON, formerly foreman boiler maker of the C. R. & P. R. R., at Cedar Rapids, Ia., has recently been transferred to the position of foreman boiler maker of the same company at East Moline, or Silvis, Ill., vice L. Feddler.

J. H. NOONAN, for several years layer-out at the Central of Georgia Railroad shops. Macon, Ga., has been appointed foreman boiler maker of the Southern Railroad shops at Birmingham, Ala., and assumed his duties there Aug. 1, 1908.

WILLIAM C. MILLER, formerly foreman of the Portland Company, Portland, Me., is about to erect a new up-to-date boiler shop in Providence, R. I. Mr. Miller was for eleven years foreman of the Atlantic Works, East Boston, Mass., and, for a time, superintendent of the large plant of the Springfield Boiler & Manufacturing Company, of Springfield, Ill. He is widely and favorably known throughout New England as a practical boiler maker and an authority on marine construction and repair.

JAMES WHITEACRE has been appointed assistant to Joseph H. Carter at the shops of the Goldie-McCulloch Company, Galt, Ontario, Can. This company has been very busy for the past two years, having completed several large contracts for British Columbia.

J. C. LASSEN, of Cleveland, has started a machine and repair shop at the corner of Main and Vine streets, Oberlin, Ohio. He will repair machinery, boilers and engines.

WILLIAM A. ROOME, who has been connected with A. M. Castle & Co. for several years in the capacity of sales agent, and prior to that with the Scully Steel & Iron Company in its sales department, has opened an independent sales agency at 943 Monadnock block, Chicago, representing manufacturers of boiler and tank plate, iron and steel boiler tubes and boiler and structural rivets.

In the annual report of the Boiler Inspection Department of Los Angeles, Cal., for 1907, Mr. J. B. Holloway, City Boiler Inspector, stated that there were 905 boilers in use in the city, comprising twenty-one different types; 1,548 boiler inspections were made during the year, and in 425 cases it was found necessary to make repairs. Too much hard scale incrustation was the cause of repairing 165 boilers, and in thirteen cases repairs were made necessary by trying to fire the boilers when there was no water in them.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—I recently inspected the manufacture of a riveted flange steel penstock about 2½ miles in length and of 30-inch, 38-inch, 48-inch and 66-inch diameters. Plates of 9-16 to 1 inch thickness were made up with triple-riveted, double-butt joints and plates from ¼ to ½ inch thickness had double-riveted lap joints. The working pressure on the lower end of the line was about 650 pounds per square inch. It was desired that in every particular the pipe be of the very highest quality of material and workmanship. All holes in the butt-joint pipe were drilled and holes in the lap-joint pipe were punched and reamed. The specifications required that no rivets be calked and all loose or defective rivets be removed and replaced. Because of faulty riveters and low-grade workmanship over a thousand rivets were loose or otherwise defective and had to be removed. The injury to the rivet holes resulting from the improper manner of removing these rivets was very great. As many similar pipe lines are being built for hydro-electric and water supply propositions, it would be interesting to hear, through the columns of THE BOILER MAKER, what tools and methods should be employed in removing rivets so that the injury to the rivet holes is reduced to a minimum. The writer would be especially interested to learn of any power device appropriate for cutting off rivet heads so as to avoid the use of the side set.

J. B. K.

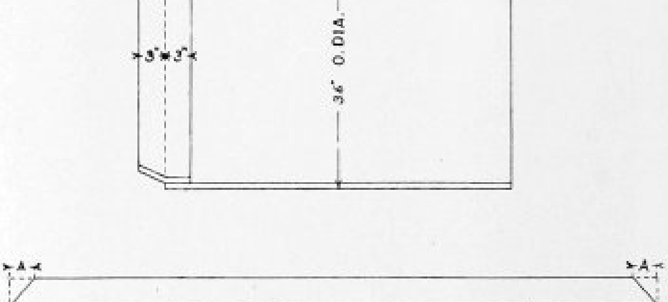
A.—The most common tools for cutting off rivets are an ordinary cold chisel, ground either flat on one side or with a double bevel and a cape chisel. After the head is chipped off the rivet is punched out with a backing-out punch. With care rivets can be removed in this way with very little damage to the plates and rivet holes. As this is an operation which nearly every boiler maker has his own way of doing, however, we shall be glad to have our readers send in a short description of the different methods which they use for doing such work.

Where the specifications call for such high-grade work, defective riveting ought not to be tolerated. With good tools and expert workmen, rivets can be driven tight without calking, and the percentage of loose rivets ought to be greatly reduced.

Q.—The sketch submitted represents a cylinder with a conical hood made in one piece to fit into one end of the cylinder. How much should be cut off from the ends of the plate which form the hood at points AA?

ARIZONA.

A.—If the hood is laid out flat and rolled into a cylindrical shape, and the tapered part of the hood flanged over, then the circumference or length of the sheet for the top edge is less than that at the flange line and bottom and the amount to be



SKETCH OF CONICAL HOOD.

cut off at *A A* will depend upon the difference in the length of these circumferences. Since the outside diameter of the cylinder is 36 inches and the thickness of plate ⅜ inch, the inside diameter of the cylinder would be 35¼ inches. The neutral diameter of the lower flange of the conical hood will be ⅜ inch less than this, or 34⅞ inches. The circumference corresponding to this is 109.56 inches. The diameter of the top of the hood is 4 inches less than that of the lower, or 30⅞ inches. The circumference corresponding to this is 97 inches. Therefore the difference between the circumference at the top of the hood and at the bottom is 12.56 inches, and the distance *A* in the layout should be approximately one-half of this, or 6¼ inches. If the hood were laid out and rolled to form the conical surface first and then the straight part flanged over, it would be necessary to trim the corners of the straight part so that the length of the bottom edge would equal the length of the flange line.

Q.—We have several water-tube boilers of the B. & W. type. We open them up in order to scale them once a year and after the second time that this was done we began to have cap-bolts break, always when boiler was cooled down and generally when it was being filled with cold water previous to starting up. It looked as though bolts had been strained too much in putting on caps. We took all the cap-bolts and annealed them and since then they have not given any more trouble. We repeat this annealing process every two years. Is it necessary to anneal the bolts as often as this? How long will it be safe to use these same bolts under these conditions before it will be necessary to condemn them and get new bolts? They have been in service five and one-half years. Size of tubes, 4 inches; size of bolts, 1 inch; pressure allowed, 150 pounds. Feed water does not corrode. C. B. S.

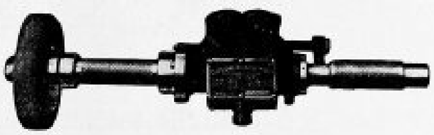
A.—An occasional annealing of the bolts will undoubtedly reduce the liability of fracture due to internal strains, but the frequency with which this should be done would depend entirely upon local conditions. If the water does not cause corrosion, the bolts could be considered safe until the threads show signs of giving out or a fracture starts.

The cause of the breakage of the bolts was undoubtedly the contraction of the bolts when they were already under excessive stress, due to setting the bolts up so hard. If the caps are set up tight enough to prevent leakage, that is all that is necessary. Any further stress placed on the bolts will only tend to cause a fracture.

ENGINEERING SPECIALTIES.

Portable Emery Grinder.

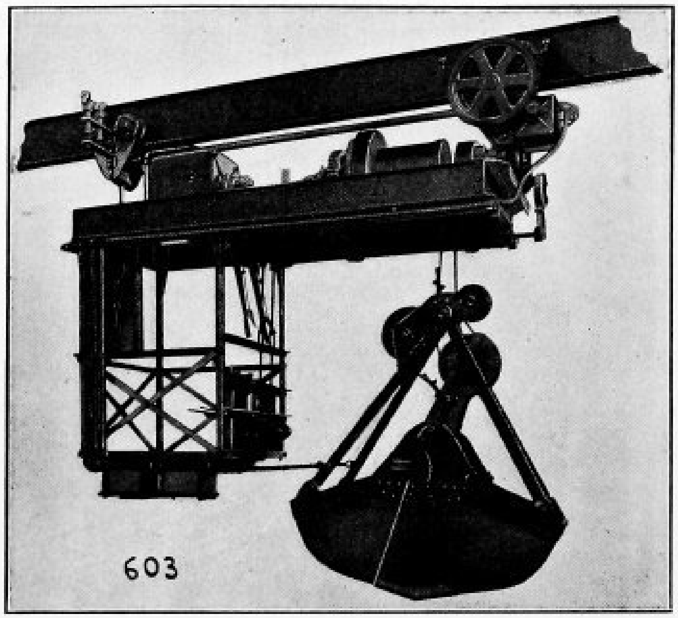
Portable emery grinders are especially adapted to grinding off fins and risers from iron and steel castings, and trimming welded seams and countersunk rivets or uneven edges of steel plate in structural or sheet-metal work. When locked in a vise, the grinder can be used as a permanent tool for edging small tools. It is a valuable addition to any field erecting outfit or roundhouse equipment. The machine illustrated,



which is manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, will drive a 6-inch emery wheel with a 1¼-inch face as a maximum size. It has a gross weight of 17½ pounds, and the length over all, including the throttle handle, is 22¼ inches. Running light, with 80 pounds air pressure, it has a speed of 2,400 revolutions per minute, and uses 20 cubic feet of air per minute. In place of the emery wheel, a wire wheel brush, or felt wheel, may be substituted for cleaning castings and buffing or polishing metal surfaces.

A Grab Bucket Mono-Rail Crane.

The Cleveland Crane & Car Company, of Wickliffe, Ohio, have placed on the market a mono-rail crane designed for use on an I-beam runway and provided with swivel trucks, so as to enable it to go around a curve of short radius. Both the hoisting and holding drums are operated by one motor. The lowering of the bucket and the operation of opening and closing same are effected by gravity, this method being considered preferable to having a separate motor for the hoisting and holding line, since the rotative speed of the armature of a series motor in lowering the load will not exceed twice the hoisting speed, whereas with a gravity fall any speed of lowering can be attained, as the motor is inoperative when the bucket is being lowered or opened. After the bucket has been lowered the clutch is closed, and then the clutch over the holding drum is engaged and the two are utilized for lifting the load. When the bucket has reached its highest position it is sustained by a self-lubricating mechanical brake, of the double friction type, thus eliminating the necessity of constant care by the operator, and the liability of dropping the bucket should his attention be interrupted at any time. In order to relieve the hoisting clutches of undue wear during the process of lowering the bucket, the hoisting drums are

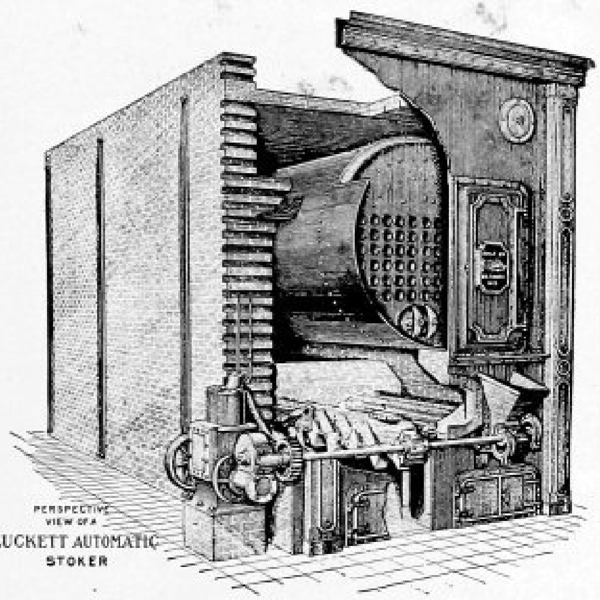


provided with band brakes, controlled by foot levers. The friction clutches used for raising the load act as safety devices in case of over-hoisting, since the clutches are so designed that they will slip before the stresses have reached a dangerous point.

A racking motor is attached to the driving truck, the speed of which can be controlled in the operator's cage. The treads of the track wheels for the driving and trailing trucks are made spherical instead of cone-shaped, in order to minimize friction. It is well known that a cone-shaped wheel running on the lower flange of an I-beam will have rolling contact along one diameter only, while the other parts of the wheel will be in sliding contact and subject to undue wear, as well as imposing an excessive load on the racking motor. This hoist is used principally for handling coal, and the particular one illustrated is designed to handle from 20 to 30 tons of coal per hour from a car or stock pile about 150 feet distant from the power house, with a vertical lift of about 60 feet.

The Luckett Stoker.

The Luckett automatic stoker has been designed by the E. J. Codd Company, 700 South Caroline street, Baltimore, Md., for the purpose of securing smokeless combustion under steam boilers, and thereby securing also an increased economy in fuel. In the furnace there are two magazines, so placed that each one will supply one-half of the width of the furnace. On the sides of these magazines are the grates, which incline downwards towards the center and sides of the furnace. Coal is fed into a hopper at the front end of each magazine. It is fed into the furnace by a device termed the "conveyor," the number of conveyors used depending upon the depth of the furnace. These conveyors oscillate about a shaft and work alternately; that is, while one is moving up the other is moving down. By this action the coal drops in front of the conveyors back under the dead plate, and as it reaches its extreme forward position the second conveyor has reached its extreme lower position and takes the coal, which has been carried forward by the first conveyor, pushing it up the inclined bottom, known as the up-take; it is then partly thrown over the top of the up-take to be conveyed by the third conveyor, and partly pushed to the fire surface. This process is repeated by the succeeding conveyors, each being set so that it will take a certain proportion of the coal, leaving the remainder to be pushed to the fire surface. This proportion is constant, no matter how fast or how slow the coal is fed. The portion of the coal in the course of being pushed to the fire surface is gradually heated and ignited, thereby forming coke. Since this process is continuous, the coke is heaped up above the magazine, which, partly through



PERSPECTIVE VIEW OF A LUCKETT AUTOMATIC STOKER

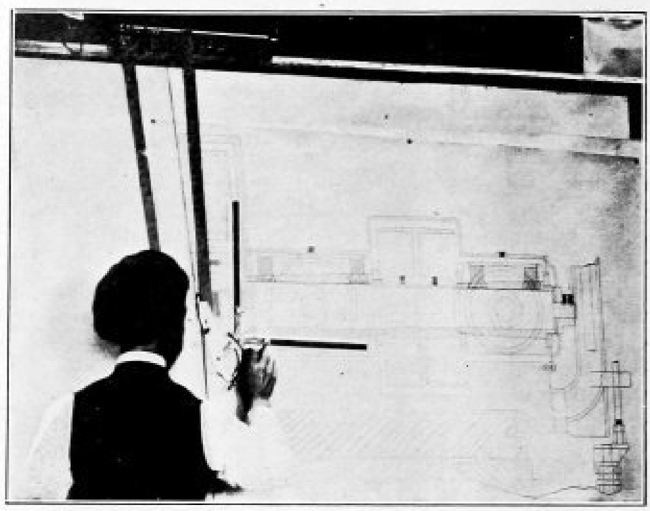
gravity and partly through the action of the fires, falls to the inclined grates on the sides and is gradually worked to the center and sides of the furnace. The conveyors of each magazine are operated by arms and rods connected to two eccentrics attached to the shaft in front of the boiler, known as the stoker shaft. This shaft is driven by an engine at the side of the boiler, connected by means of a reducing worm and spur gears.

The principle of feeding the coal continuously into the furnace below and the lifting effect of the conveyors does away with the opening of furnace doors for firing and slicing the fires. This saves the boiler and furnace from the objectionable inrush of cold air, and, therefore, tends to eliminate smoke.

A New Drafting Instrument.

The Emmert Manufacturing Company, of Waynesboro, Penn., have undertaken the manufacture and sale of the Noyes vertical T-square, a drafting instrument which comprises a vertically arranged T-square, guided at the top of the drawing board upon which is a protractor with vertically sliding scales. The head of the T-square is provided with a set of four rollers guided upon a straight steel track which is fastened to the top of the drawing board. One pair of these rollers is beveled and runs on ball bearings, so arranged that the weight of the head holds it upon the track with absolutely no lost motion, making possible a very free and sensitive movement. The head also carries a spring-balanced drum, to which is attached a cord, which connects with the vertically sliding protractor and acts to hold the latter to the blade. The protractor is also guided upon the blade by rollers, giving it a very sensitive vertical movement. It is thus evident that the instrument always moves in horizontal and vertical parallel lines.

Pivoted to the sliding protractor is a forked arm to which interchangeable scales are attached. This arm is provided with a worm, which engages notches cut in the rim of the protractor, and which can be quickly pressed out of engagement. These notches are spaced 3 degrees apart, thereby making possible an instantaneous setting of the instrument to any mul-



tiple of 3 degrees, which includes all the most commonly used angles: 0, 15, 30, 45, 60, 75 and 90. The 3-degree angle is exceedingly handy, as it is the usual draft given to patterns, and is suitable for the conventional angle used for showing screw threads and various other cases.

To obtain fine adjustment, the neck of worm is graduated with twelve divisions, so that one division represents ¼ of a degree. One-half of this, or ⅛ degree, can be easily reached, which is as fine as is ever necessary for drawing. Interchangeable scales are provided, furnished with any desired graduations.

SELECTED BOILER PATENTS.

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Washington, D. C.

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

888,659. WATER GAGE. Pearl I. Scott and Arthur E. Corbett, of Ogden, Utah.

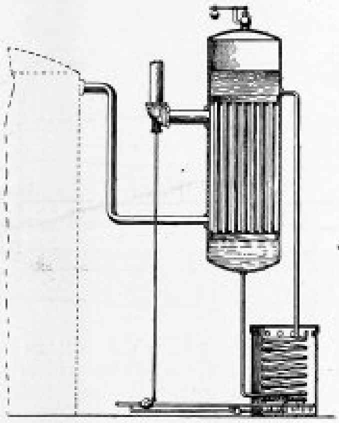
Claim.—A water gage comprising a back section, an angular front section provided in its side with observation openings, heads closing the upper and lower ends of the water-receiving chamber formed by said sections, the parts being suitably united, and an angular glass held between said sections and covering the observation openings. Two claims.

893,028. SAFETY DEVICE FOR STEAM BOILERS. James E. Smith, of El Paso, Tex.

Claim.—The combination with a body, of a valve stem guide secured thereto and provided with ports, a fuse plug valve mounted within the guide and held against rotary movement relatively thereto, a valve stem having a swivel connection with the fuse plug valve, and a combined valve and nut for connecting the fuse plug valve and the valve stem and operating, when the plug valve is seated, to permit the escape of steam for the purpose of sounding an alarm. Two claims.

889,147. APPARATUS FOR SUPERHEATING STEAM. Eugene F. Osborne, of Chicago, Ill., assignor to Osborne Steam Engineering Company, of Chicago.

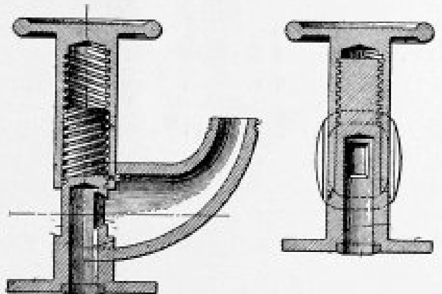
Claim.—An independently fired steam heating apparatus comprising, in combination with a steam generator, a superheater arranged between the generator and point of use of the steam through which the steam passes to its point of use, said superheater embracing a passage or passages in which circu-



lates a liquid, through which liquid and the walls of the passage or passages the heat to superheat the steam is transmitted, a source of heat independent of that which heats the steam in the generator for heating the said transmitting liquid, and means for varying the intensity of the heat applied from said source to the transmitting liquid. Three claims.

889,941. VALVE. Thomas William Lowe, of Winnipeg, Manitoba, Canada.

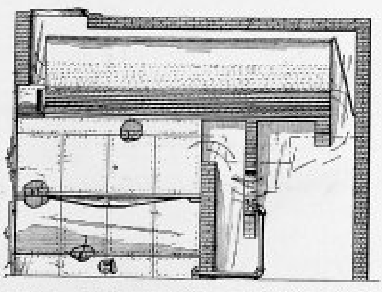
Claim.—The combination with the stationary barrel, means for securing said barrel to a boiler or other receptacle, said stationary barrel having an internal chamber and an outlet port communicating therewith and provided with a seat, a



movable barrel telescoping over said stationary barrel, and adapted to rest on said seat to close said port at times, means for telescopically moving said movable barrel along the stationary barrel, and an off-take spout formed with said stationary barrel to co-operate with the discharge port thereof, and partially embrace the movable barrel, substantially as shown and described. Five claims.

889,976. FURNACE. Charles Schweizer, of Maplewood, Mass., assignor to American Heating Company, of Boston, Mass., a corporation of Maine.

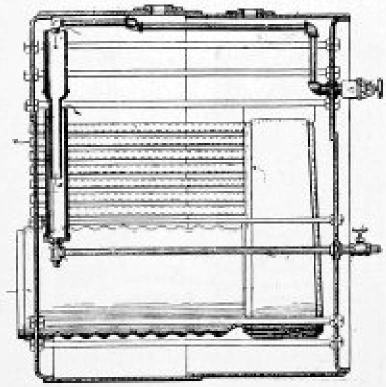
Claim.—In a boiler furnace, the combination of a fire-box, means constructed to supply air for combustion, passages ar-



ranged to shunt a portion of the products of combustion directly from the fire-box to the boiler, air passages disposed in the walls of the fire-box and provided with apertures arranged to permit admixture of air with such shunted portion of the products, spaced, hollow perforated blocks arranged in the path of the remaining products, and an air pipe connecting said air passages and spaced, hollow blocks, whereby air is intimately intermingled with such products during their passage through the spaced blocks. Three claims.

891,399. FEED-WATER HEATER. Douglas Brews, of Cleveland, Ohio.

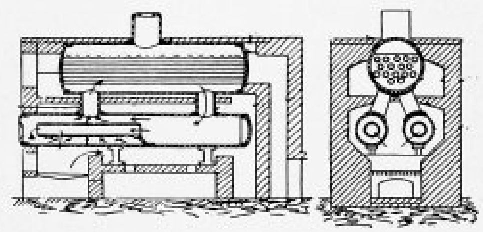
Claim.—A steam boiler, a combined surface scumming and blow-off receptacle of tubular shape erected vertically in the front end of the boiler and having its upper end open full width and substantially even with the water level in the



boiler, a feed-water heater of tubular form having a relatively reduced lower end immersed in said receptacle and discharging thereinto below said water level and having its upper half open full width at its top and exposed its full depth to the steam in the boiler, a feed-water pipe extending lengthwise through the top of the boiler and discharging at its end directly into the open mouth of said feed-water heater, and a valve-controlled discharge pipe leading from the bottom of said sediment receptacle. One claim.

891,731. MUD COLLECTOR FOR STEAM GENERATORS. Henri Poron, of Troyes, France.

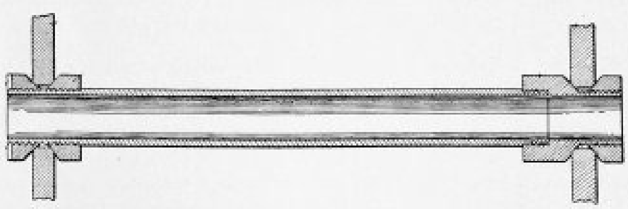
Claim.—The combination with a steam generator consisting of an upper water tube, a lower water tube, and short upright tubes connecting the upper and lower tubes, of a mud-collecting tube open at both ends and arranged within the lower



water tube and spaced therefrom on all sides, and so positioned relatively to the short upright tubes as to cause the water circulating within the lower tube to pass through said mud-collecting tube before it passes upwardly through one of the upright tubes and deposit its sediment within the said mud-collecting tube. Two claims.

891,783. BOILER FLUE FASTENER. William E. Parkinson, of Crown Point, Ind.

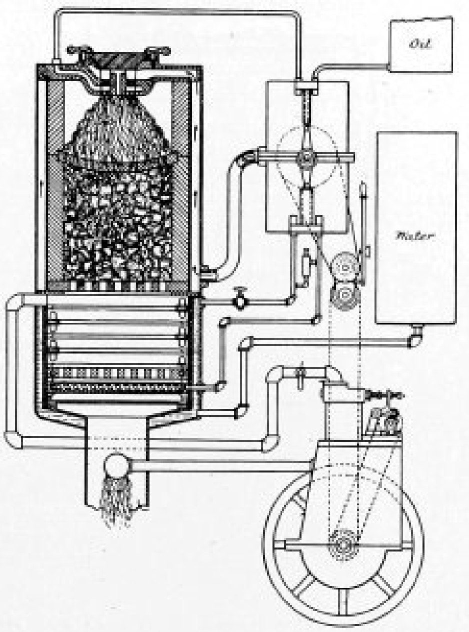
Claim.—The combination with the flue sheets of a boiler, of a tube having one end secured for longitudinal adjustment in one of the flue sheets and its other end terminating short of the other flue sheet, a thimble threaded on the latter end



of the flue and having its bore of the same diameter as that of the flue, and provided with a reduced threaded extension projecting through and beyond the last-named flue sheet, and with a tapered shoulder bearing against the interior edges of the flue opening through which the extension projects, and a nut screwed onto the projecting end of the thimble and having a tapered shoulder bearing against the exterior edges of the flue opening. One claim.

892,196. STEAM GENERATING APPARATUS. Elihu Thomson, of Swampscot, Mass., assignor to General Electric Company, a corporation of New York.

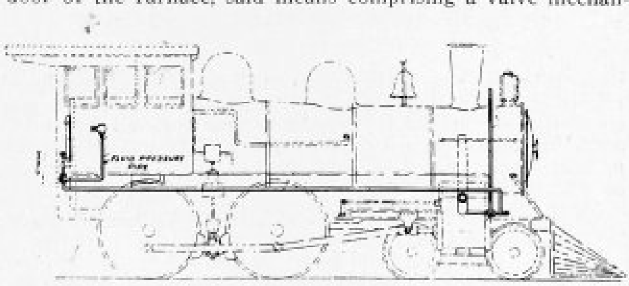
Claim.—In a steam generating system, the combination of a boiler capable of superheating steam, a burner, pumps for feeding water to the boiler and fuel to the burner, which



pumps differ as to their capacities, pistons for the pumps which are mechanically connected, means for operating the pumps in a manner to preserve the relation between the capacities, and means which is independent of the operating means for simultaneously varying the capacities of the pumps while preserving their definite relation. Nine claims.

892,565. DRAFT REGULATOR FOR BOILER FURNACES. Gabriel Steele, of Sioux City, Ia., assignor of one-half to Fred L. Eaton, of Sioux City, Ia.

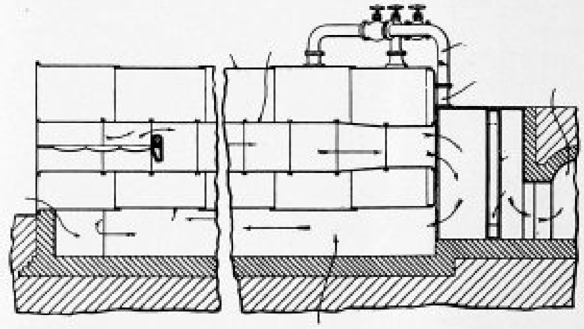
Claim.—The combination with a boiler furnace and its exhaust nozzle and passages, of means for automatically shunting the exhaust from the nozzle upon the opening of the fire-door of the furnace, said means comprising a valve mechan-



ism open to the atmosphere and controlling the communication between the exhaust passages and the atmosphere, a compressed air cylinder, a piston mounted therein and operatively connected to the valve of the valve mechanism to open the same, a fire-door, an air pipe adapted to admit air under pressure into the cylinder, a valve in said air pipe, and an operative connection between the fire-door and said valve. Six claims.

894,566. SUPERHEATER FOR STEAM-BOILERS. William Ackroyd, of Wortley, Leeds, and Crossley Anderson Montgommery Buckley, of Batley, near Leeds, England.

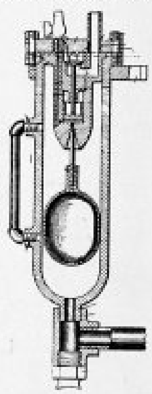
Claim.—In superheaters for steam boilers; the combination with a steam boiler, a furnace for heating same, and flues for conducting the products of combustion; of a vertical box-like casing located at the rear of said boiler, the vertical ends of said casing abutting upon the rear end of said boiler, said casing being shaped in plan to form a chamber between the inner wall of said casing and the rear end of said boiler, into which chamber said flues of said boiler open, vertical division plates located in said casing, one of said division plates not reaching the top of said casing and the



next division plate not reaching the bottom of said casing to provide a circuitous path for steam within the said casing, a pipe from said boiler communicating with the top of said casing at one of the ends of said casing abutting upon the rear of the boiler to conduct steam thereto, and a steam delivery pipe communicating with the top of said casing at the opposite end thereof to convey away the superheated steam. Four claims.

893,036. SAFETY DEVICE FOR STEAM BOILERS. John Ulrich and Charles Letteri, of Columbus, Ohio.

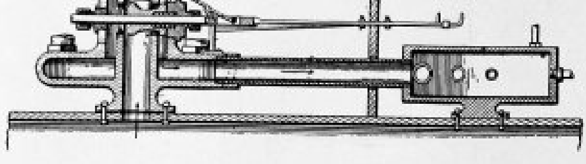
Claim.—In a device of the character described. the combination with a steam boiler, of a casing, a pipe leading from said



steam boiler to said casing, a pipe leading from said casing to the fire-box of the boiler, and a valve mechanism located within said casing and adapted when the water in the boiler drops to a predetermined level to admit steam at boiler pressure to the pipe leading to the fire-box. Four claims.

893,389. AUXILIARY DOME FOR STEAM BOILERS. James Shelton, of Knoxville, Tenn.

Claim.—The combination with the locomotive and the fountain, of an auxiliary steam dome in connection with the boiler and communicating therewith, a pipe connecting the dome with the fountain, a spring-actuated valve for normally closing the communication of the dome with the boiler, a toggle



for retaining the valve in open position, and means for breaking the toggle whereby to release the valve. said means comprising a shaft having an arm for engaging the toggle to break the same when the shaft is oscillated in either direction, a link for oscillating the shaft, said link having a lost-motion connection with the wall of the cab, whereby when the cab is displaced the shaft will be oscillated to release the toggle. Ten claims.

THE BOILER MAKER

VOL. VIII OCTOBER, 1908 No. 10

THE PHILADELPHIA IRON WORKS.

BY CHARLES E. FRICK.

The plant of the Philadelphia Iron Works, a general view of which is shown in Fig. 2, is located on the Reading Railroad at Eighteenth Street and Pennsylvania avenue, Philadelphia, Pa. This location gives excellent facilities for economical shipping. The main shop is 70 feet wide, 160 feet long, with a main bay 36 feet wide. There is a large vacant lot in the rear of the building which the company intends to utilize in the near future for an extension to its plant.

Material is handled in the shop by a 10-ton overhead traveling crane, which spans the main bay of the shop and travels its entire length. This crane, as well as the one in the riveting tower for handling work at the hydraulic riveter, is operated by electricity. In other parts of the shop jib cranes are installed for handling the work at various machines. These cranes are equipped with Harrington chain hoists of 3 tons capacity.

Fig. 4 is a view taken from the center of the shop, looking southwest. An idea of the arrangement of some of the most important machines in the shop can be obtained from this view. At the extreme left a large radial drilling machine is shown. This machine is manufactured by the Baush Machine Tool Company, and has a capacity for drilling twenty 4-inch tube holes through 9/16-inch plate in one hour. Beyond this is a high-speed radial drilling machine, manufactured by William E. Garr & Company. The power bending rolls are located at the end of the shop. These rolls are 12 feet long between housings, and have a capacity for rolling 5/8-inch plate. A large punch can also be seen in Fig. 4 of the Williams, White & Company's make, with a 36-inch throat and, a capacity of punching a 1-inch hole through a 1-inch plate. At the extreme end of the shop an overhead trolley is installed for unloading and placing the material preparatory to laying it out.

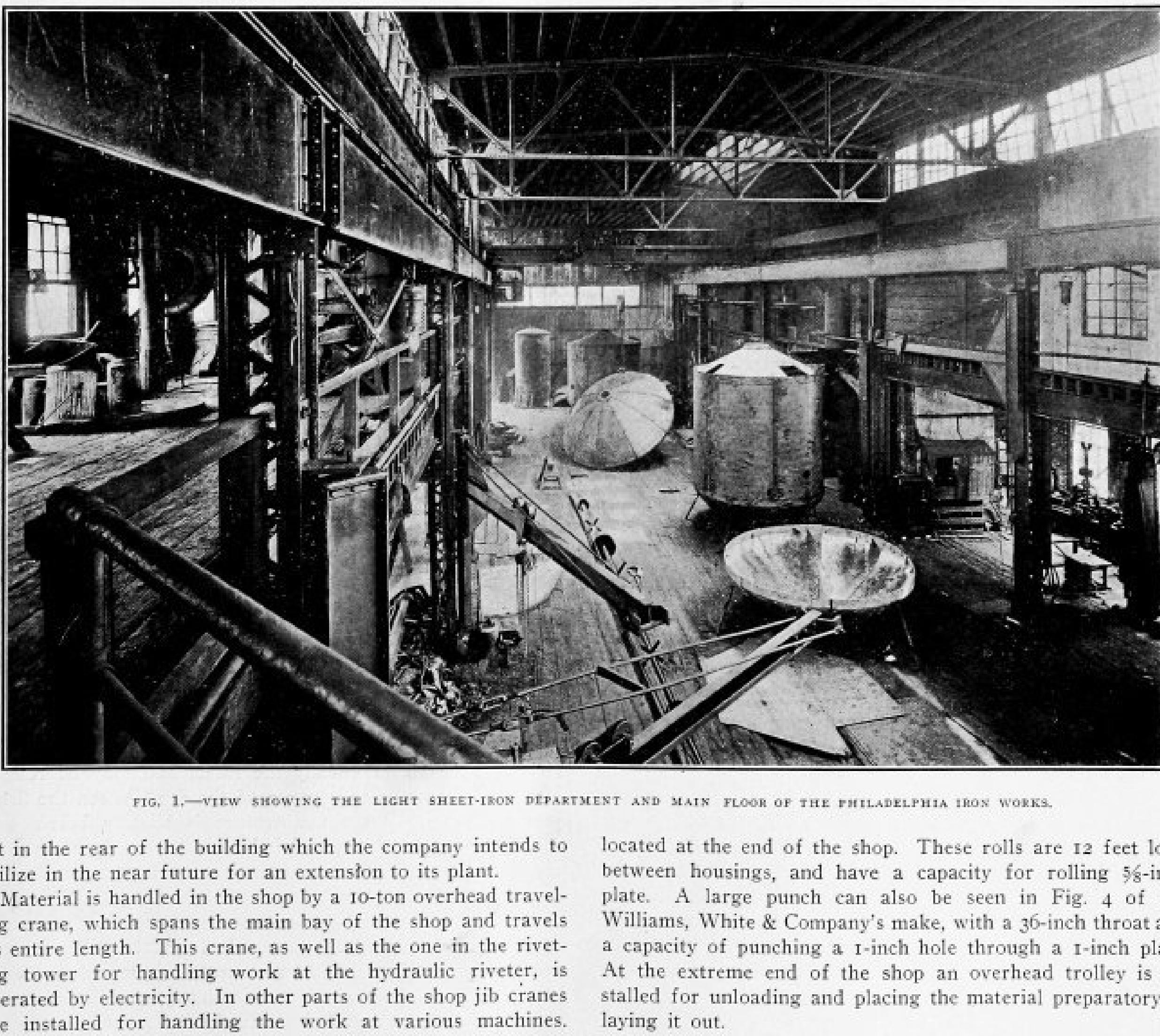


FIG. 1.—VIEW SHOWING THE LIGHT SHEET-IRON DEPARTMENT AND MAIN FLOOR OF THE PHILADELPHIA IRON WORKS.

On the second floor of the building is a small machine shop for making and repairing various tools, and also a tool room where all the small tools, such as pneumatic hammers, drills, etc., are taken care of. On the other side of the shop on the second floor is the light sheet-iron department. The equipment for this department includes two quick-acting punches, one with a 24-inch throat and the other with a 6-inch throat. There is also a set of 5-foot power bending rolls, and a 96-inch Allen riveter, which is especially installed on a frame. Besides these there is a 96-inch hand-power break for flanging material up to ¼ inch thickness. This department is used for all classes of work where the material does not exceed ¼ inch in thickness.

The hydraulic riveting machine can be seen in Fig. 3. This riveter is what is known as a hydraulic pneumatic riveter, and is manufactured by S. S. Caskey. It has a 12-foot 6-inch stake, and its maximum pressure of 125 tons makes it capable of driving 1¼-inch rivets. Work is handled at the riveter by an overhead electric crane and hoist of 10 tons capacity, which is very easily operated by the man who is operating the riveter without stepping away from the machine.

The blacksmith and flanging fires cannot be seen in any of the photographs, but some of the work that has been finished on the fires is shown in Figs. 1 and 4. Attention is called particularly to the round bottom tanks, some of which have a flange 7 or 8 inches deep turned on them after they have been bumped out to shape. Those shown in Fig. 1 are for use in jacketed kettles, 15 feet in diameter, constructed with two bottoms, which are riveted together and stay-bolted, to resist a steam pressure of 100 pounds per square inch.

Besides the tools already mentioned, the shop is equipped with a Lennox bevel shear and a Lennox splitting shear, both of which have a capacity for shearing a ¾-inch plate. There is also a Hilles & Jones double angle shear with a capacity of 5 by 5 by ½-inch angles, and a Hilles & Jones punch with a 36-inch throat and a capacity of punching a 1-inch hole through a 1-inch plate. The equipment of small tools includes all the latest improved pneumatic drills, chipping and riveting hammers, holder-ons, etc. Power for the shop is furnished by a 150-H. P. internally-fired boiler of the company's own make, and an 80-H. P. engine and 40-kilowatt generator. Compressed air is furnished by an Ingersoll-Sargent compressor having a capacity of 350 cubic feet of air per minute.

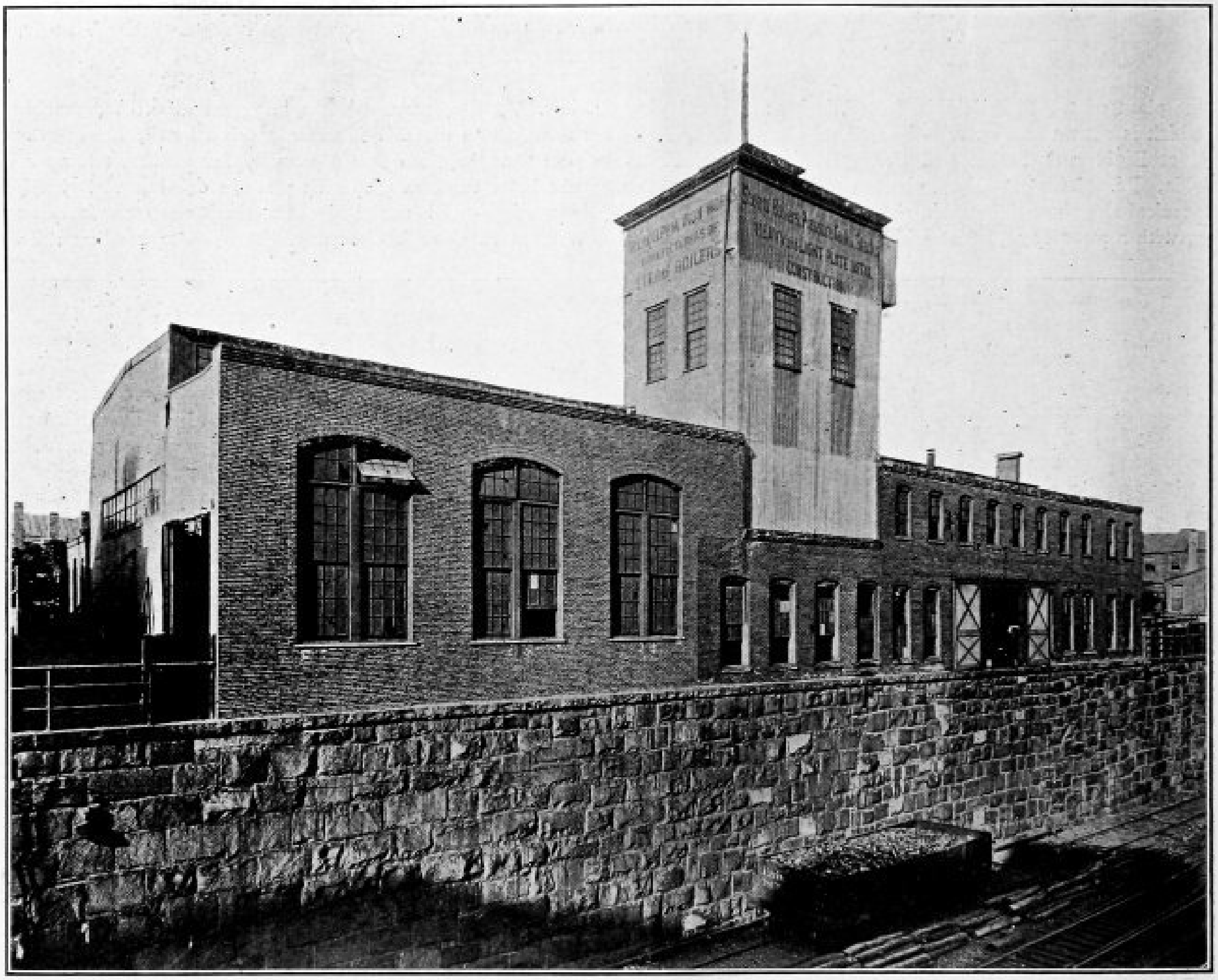


FIG. 2.—GENERAL VIEW OF THE PHILADELPHIA IRON WORKS.

The temperature for all kinds of combustibles under similar conditions is practically the same, and may be roughly estimated from the appearance of the fire. When the fire is just a visible red the temperature is slightly below 1,000 degrees F.; at a cherry red it is about 1,650 degrees; at an orange, about 2,000 degrees; at a white heat, 2,370 degrees, and at a dazzling white heat, 2,730 degrees.

According to Dr. Grossman, boiler plate will not suffer from corrosion if magnesium waters of carbonate of lime be present; but, if an insufficient softening process has first been carried out, corrosion is intensified. As regards sea water, carbonate of lime will not prevent corrosion, but slacked lime will do so at such temperatures as are used for its distillation. Marine engineers have long ago found the value of lime as an anti-corrosive agent, and they frequently use it to obtain an eggshell scale.

FIG. 3.—MAIN FLOOR OF THE SHOP.

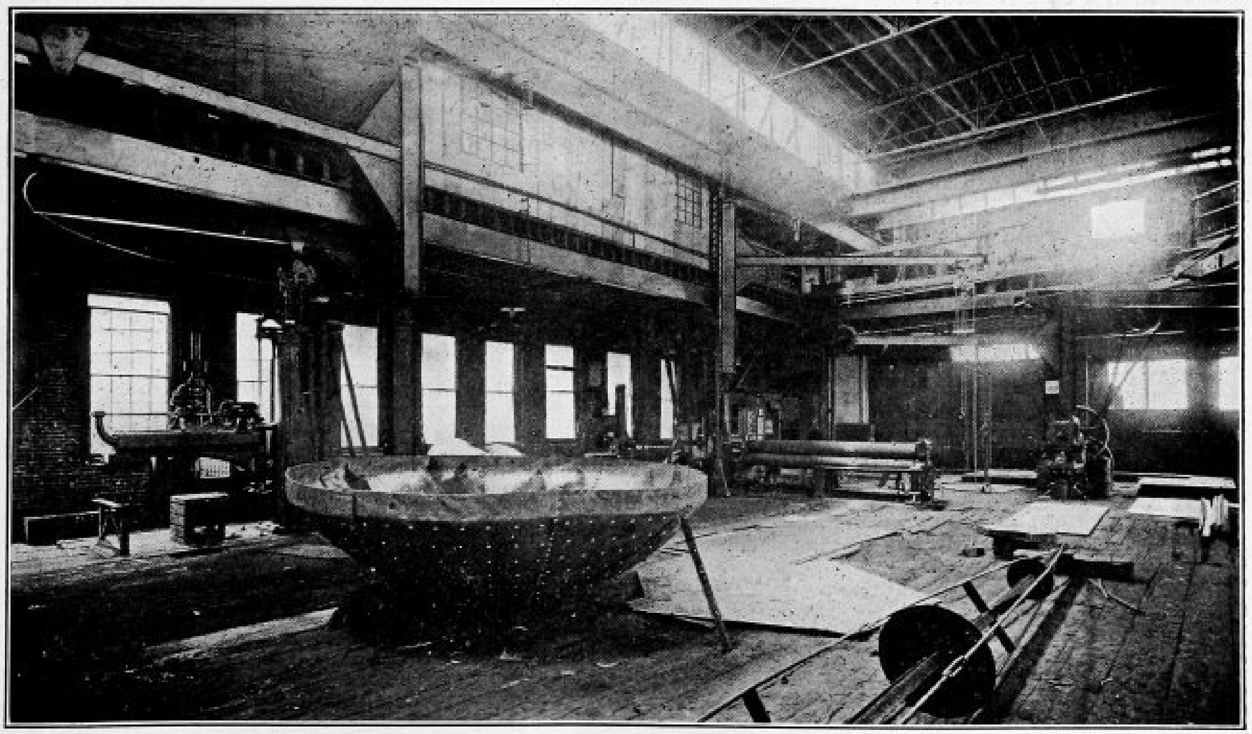


FIG. 4.—LOOKING SOUTHWEST FROM THE CENTER OF THE SHOP.

Advantages of the Automatic Stoker as Compared With Hand Firing for Locomotives.*

BY G. C. GRANTIER.

In this paper on advantages of the automatic stoker as compared with hand firing, I shall endeavor to give not only the advantages but the defects as well.

I have before me a large number of letters from members of the association and others interested in the subject, for which I wish to thank all concerned.

We have had Victor, Kincade, Lucky, Straus, Crosby and Monarch stokers, mentioned as being able to fire an engine successfully. The Monarch stoker is operated either by steam or air and by a ⅜-inch pipe connection. The coal is placed by the fireman with a scoop in the hopper and is forced by a series of pistons with varying strokes.

The information that I have been able to get on these stokers, outside of the one with which I am particularly familiar, is not given in detail, so I cannot describe each one, but I hope you will feel at liberty to do so here. The one about which I intend giving the most information is the one that we have been operating on our system.

All of the stokers are very similar in operation, either by a series of pistons or plungers which produce longer or shorter exhausts or strokes or steam jets, and tend to throw the coal closer to the flue sheets or the back end of the fire-box, and spread the coal very uniformly over the grate surface. Some of them use deflection plates to spread the coal.

The stoker we have on our division and in operation was installed last June, and is known as the Hayden stoker. The method of operation is as follows: First, the coal is taken from the tank by an elevator through a grating with 3-inch openings operated by a quadruplex engine, then passes into a conveyor and is elevated to the conveyor located over the fireman's head, and is dropped into a hopper over the fire-box door by a worm screw, and falls by gravity through a slide gate opening in the top of the fire-box door on a table located just inside the fire-box door, 24 inches long and 7 inches wide, and is blown by a blast of steam varying in length as desired by five separate nozzles or jets in the fire-box door, which have a tendency to cool the table and prevent its burning out. The center jet blows the coal toward the flue sheet. The next two jets on either side are located to place the coal in the front corners of the fire-box. The two outside jets are located so that the coal will be distributed along the sides and the back corners of the fire-box. They are governed by separate valves to regulate the blast of steam through each valve by common steam valves, and can be adjusted at will at any time. In operating this machine we found it desirable to run the front jet closed all the time, as it is not needed on the engine on which we operated it, the next jets a turn open and the back ones full open.

The steam that furnishes the blast to place the coal is controlled by a quadruplex engine located on the back end of the boiler butt, which has a crank movement actuated by a screw-wheel, operating a control valve, which admits steam through a 1-inch pipe passing to the nozzles, which are regulated by means of a globe valve. The control valve, as a general proposition, is only run one turn open, and varies with the weight and amount of coal to be handled. The length of blast is governed largely by the raising or lowering of the latch on the trip valve and the rapidity at which the engine is run. The faster the engine is run the less coal is thrown at one blast. If desired, the valve can be tripped by hand and all of the coal in the hopper can be blown into the fire-box. In fact, the fire can be covered black inside of half a minute.

*From a paper presented before the Traveling Engineers' convention.

The steam connection to the engine operating the stoker conveyor is by 1-inch pipes. The steam connection operating the stoker engine is by ⅜-inch pipe, which is only open probably a quarter of a turn.

The efficiency of the stoker in distribution of coal as compared with hand firing can be better illustrated by referring you to the coal test recently made on our division. In this test the stoker had to compete with some of the best firemen we had on the division. Ordinarily coal used in service is 50 percent Blossburg, which contains from 15 to 35 percent ash, and 50 percent Dagus coal; but to be sure of getting a uniform grade of coal it was decided that nothing but the best Dagus coal should be used, as we have made a test both with and without a stoker. The engine was drafted for the mixed coal, and stronger than it would have been if Dagus coal was to be used. If the mixed coal had been used, I am inclined to think that the steam pressure would have been more favorable to the stoker than it is in the present performance, but taking it all in all the performance was very satisfactory for an engine that had been out of the shop for ten months since having received general repairs, and was in good condition for an engine that had been out for this length of time, although the motion work was slightly worn.

I have known this stoker, on various occasions, to fire an engine 30 and 40 miles, and even further, without having to touch a rake or open a door, and on opening the door the fire was found to be absolutely level.

With the Monarch stoker it is claimed that the labor is reduced about one-third; with the Hayden it depends largely upon the condition of the coal. If the coal is sufficiently fine so that it will not be necessary to crack it up so that it will pass through the grate, the work is about as easy again, and if necessary to crack it up the work is about as hard again. With the Monarch stoker, it is claimed, it is no labor at all to open the fire-box door, as the stoker can be easily removed by the fireman, provided it is necessary to open the door, and when the stoker is properly adjusted it is not necessary to open the door as long as the steam pressure is maintained, which will be indicated by the quality of smoke and pressure of steam furnished. The same will apply to the Hayden stoker. Occasionally coal will pile up in some place in the fire-box, making it necessary that it be leveled down, and may be caused by a clinker forming or a little deviation in front of engine and holes in grates. All that is necessary is to close the hopper, blow the coal off the table and the door can be easily opened, and the fire leveled with a rake if desired. There is nothing to be removed, and it is a very easy operation, nearly as much so as though the engine was being fired by hand, but if the stoker is properly adjusted it is not necessary very often. If the nozzles are not properly adjusted the coal will be banked in one place or another, and the labor is immensely increased over hand firing.

The knowledge of the mechanism of the Monarch, I am advised, can be acquired by a competent fireman so as to handle it successfully after one trip. The same would apply to the Hayden stoker. Of course, the greater knowledge of the mechanism of the stoker, as well as any other machine, the better we are prepared to operate to the best advantage. The natural width of the fire-box at which the Hayden machine can be operated successfully, as given by the builders, is any fire-box that can be operated successfully fired by hand. The same applies to the Monarch. The fire-box we are operating you will find given in the description of the engine. It is claimed that the stoker can be operated in a Wootten fire-box the same as a single-door fire-box, by using two stokers.

As far as plugging the flues is concerned, we have practically no trouble. So far as leaky flues are concerned, we have had no failure of flues that could be traced to the stoker in the length of time it has been in operation with us (only two, all told), which has been ten or eleven months. In fact, the boiler men advise me that they have noticed on various occasions that the flues were practically clean when the engine came into the terminal and required no flue work, which speaks well for the stoker. The reason I give for this is that the coal is fed in such small quantities and properly prepared, so that if any coal is carried into the flues it is sufficiently fine as not to stop in the flues and clog up, with draft equal through all flues.

The ability to maintain the maximum steam pressure is better than with the average fireman, and I find that the tendency of engineers who have been running an engine with a stoker is to work the engine harder than for hand firing, and this would get the train over the road in less time.

The efficiency of the stoker depends upon the elevator being properly set and adjusted in the tank, and with the experience and knowledge of the machine I have had I believe it would pay every railroad company to see that their engines are equipped with self-cleaning hopper tanks, if the stoker is to be used, so that the last of the coal in the tank will be run to the elevator if possible. This will give ample time for the fireman to watch the operation of the machine and signals, and the labor will not be burdensome to him. Heat will also be eliminated almost entirely so far as the fire-box is concerned by the use of the stoker. I have noticed that where the stoker is used it is not necessary to clean the fire as often as with hand firing. I believe, as a general proposition, that the stoker produces less clinkers, and if the grate has sufficient opening for air the gases and carbon will be burned and a more uniform pressure of steam can be maintained, with a material saving in coal, as a higher temperature can be maintained in the fire-box.

The Monarch people claim that a lump of coal as large as a man's head can be used, which means run of mine coal. From my observation of the stoker any size of coal that will go through a 3-inch opening will give the best results, and I believe that all will agree that when firing engines of any class if we have as uniform size of coal as possible, instantaneous combustion will take place.

We have tried the wash-fine coal, such as used by blacksmiths, but with very poor success. The stoker did equally as well as could be done by hand firing, but I do not think it possible to use that grade of coal to advantage, as it lays very close and is liable to pile up, causing the fire to burn full of holes. To get best results the coal should be prepared, either by crushing or screening, before it is put on the engine, and coarse coal put on passenger engines. I do not think it possible to get the best results with any stoker unless the coal is conveyed to the fire-box by means of a conveyor, as it requires practically the same labor as would be necessary if the man was to fire by hand, with the exception of eliminating the heat; I believe that the additional care of watching the stoker will more than compensate for any elimination of heat that may be made by increased labor when the conveyor is not used.

If elevators or conveyors are used and properly set with a self-cleaning hopper tank so that the coal will run down and is properly controlled so that it will be prevented from plugging the elevator, the decrease in labor will be very noticeable, and will materially aid the fireman and insure his giving closer attention to the operation of the stoker and signals, with a material saving in fuel.

For the length of time this stoker has been in service on our division the repairs have been very light. The greatest expense has been caused by the table burning out. I cannot give the exact number, but I should say eight new tables have been applied. The cross-heads on the engines have had to be reduced from time to time, and some light repairs have been made, mostly pipe work. The stoker has been out of service at different times on account of not having the proper material on hand to repair it at once. Of course, this would be expected, having but the one in service.

In the winter one of the hostlers allowed the conveyor engine to freeze up, bursting one of the cylinders. The pipes should be properly insulated to protect them from the severe weather, as the condensation taking place is considerable. The stoker is furnished with five-eighths of a quart of valve oil for each 140 miles, and requires one-fourth of a quart of engine oil.

I believe I am perfectly safe in saying that with a stoker properly installed and set in a tank, and coal prepared to a uniform size that can be handled by the stoker, the fireman can operate the engine with a saving of at least 33 to 50 percent labor, at the same time maintaining a uniform pressure of steam with a large reduction of leakage of flues and furnishing steam under all conditions better than can be done by hand firing and with a saving of fuel. A lower grade of coal can be used with the stoker than without. By this I do not mean that the grade of coal with 30 or 40 percent ash can be used successfully with a stoker against the fireman having the average run of mine coal.

There has been a good deal of fault found by the fireman, not with the stoker, as many have expressed themselves as highly pleased with it, but with the additional labor of crushing the coal as finely as need be to go through the grating. I am of the opinion that the stoker has come to stay, as I know this one can do all that is claimed for it if the care is taken of it that it is entitled to. By this I do not mean that it will not fail if not taken care of. The method of distribution is solved, but it may be further simplified.

Furnace Design in Relation to Fuel Economy.

BY E. G. BAILEY.*

In designing a boiler plant, the ultimate object is to obtain the required steam at the desired pressure, temperature or quality at the least cost. The least cost does not include the coal bill alone, but, in addition to this, consideration must be given to cost of labor necessary for the operation of the plant, repairs, interest and depreciation on capital invested. A saving in the fuel bill alone in new plants or furnaces is not sufficient to prove conclusively that any particular design is the best. The labor necessary for economical operation, together with more rapid burning out or wear of certain parts, may more than offset the saving due to boiler efficiency alone.

The majority of the boiler plants in New England running 24 hours a day consume in one year coal amounting in value to more than the original cost of the plant, so that it would pay to tear down a new steam plant before it had ever been operated if you could prove that by so doing you would make a saving of 5 percent. There are many plants which have been in operation five or ten years that could be reconstructed to-day at a saving of 5 or 10 percent. The question is, why do they continue to operate that plant when the coal being used each year costs more than did the plant when it was originally built? In most cases it would be necessary to make only a few changes to greatly increase the efficiency. In order to determine what saving might be made in the design of furnaces, it is necessary to know the magnitude of the various losses as they exist under the present conditions. It is useless to expect a saving of 20 or 30 percent from the use of certain auxiliary apparatus, as is often claimed, when the losses supposed to be reduced are far from being as great as the contemplated saving.

The heat balance of a boiler test as given usually includes the following distribution of the total available calorific value of the coal:

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(Read before the Boston Society of Civil Engineers, December 18, 1907.)

(1) Heat used for evaporation of water in boiler.

(2) Loss due to latent heat in moisture formed from the combustion of coal.

(3) Loss due to products of combustion, or sensible heat of gases produced exclusive of excess air.

(4) Loss due to air excess, or sensible heat of unused air leaving boiler.

(5) Loss due to unburned gases, consisting of carbon monoxide, hydrogen and hydrocarbons.

(6) Loss due to unburned coal or coke dropping into the ash pit or passing through flues or up the stack.

(7) Loss due to radiation from boiler setting and absorption by brick setting.

The relative magnitude of the above losses varies greatly, depending upon the kind of boiler, furnace, rate of combustion, and method of firing. The results recently determined from eighteen evaporation tests on a 200-H. P. return tubular boiler, hand fired, give some idea of the relative importance of the various losses as they occur in a stationary plant. The average of the above tests is as follows:

1. Heat used for evaporation	66.7
2. Loss due to latent heat	2.7
3. Loss due to products of combustion	8.5
4. Loss due to air excess	8.5
5. Loss due to unburned gases	0.8
6. Loss due to unburned coal	2.4
7. Loss due to radiation and absorption	10.4
Total heat	100.0

The important item is the heat used for evaporation or the boiler efficiency, which can be increased only by the reduction in one or more of the various losses as they now exist. The extent to which these losses may be reduced is dependent upon the kind of coal, method of firing or supply of coal and air, conditions under which combustion takes place, and extent and conditions of heat-absorbing surface.

Latent Heat or Moisture in Coal.—This loss includes not only the evaporation of the moisture in the coal as usually determined but that formed from the combustion of hydrogen as well. This loss is of small importance and varies but little for the different coals received in this market. It is a loss that is impossible to reduce, but it may be prevented in certain cases where coal is intentionally wet by the fireman.

Products of Combustion.—The amount of gases produced from the combustion varies almost directly with the calorific value of the coal, so that the percentage of loss is practically constant except for variation in the flue temperature, which depends upon the rate of combustion, area of boiler heating surface and cleanliness of the same.

Air Excess.—This loss is one of the greatest importance, as it causes a loss of 30 percent or more. It not only carries away sensible heat, but reduces the furnace temperature, thereby reducing the efficiency. This loss may be affected to some extent by the character and quality of coal burned. A non-coking coal generally lays closer together and is less apt to allow holes to burn in the fire than a coking coal; also the formation of clinkers causes the air to pass through the fire in streams, thus causing high velocity in certain parts, and a hole is the result.

The fireman is largely responsible for the loss due to air excess, because he does not keep the fire to the proper thickness for the draft, or he may fire the coal unevenly, allowing holes or thin spots to form. A series of tests was once made to determine the air excess with different thicknesses of fire, with uniform conditions with respect to draft, kind of coal, etc. The results showed a saving of 6.5 percent, with a fire 12 inches thick over one 4 inches thick.

The best method of determining the extent of this loss is by analyzing the gas leaving the boiler. This is usually done with the Orsat apparatus, but the automatic continuous recording CO_2 machines now on the market make it much easier for the fireman to keep his fire in good condition, and the effectiveness of his work is permanently recorded. The tendency on the part of the fireman is to disregard such an apparatus, especially after it has gotten out of repair once or twice, but it is only through interest on his part that economical results can be obtained. One percent of CO_2 means about 20 percent air excess, or 2 percent loss under average conditions of air excess and temperature.

The air excess as determined at the up-take from a boiler, or at the bottom of the stack, does not always show what the fireman is doing, as the air leaking through cracks in the brickwork around clean-out doors, and even the porosity of the brickwork, is oftentimes as great as or greater than the excess air passing through the furnace.

Unburned Gases.—Usually the analysis of flue gases gives the carbon monoxide as the only unburned gas, but there are undoubtedly other gases that are not completely burned that are of higher calorific value than CO. They are seldom determined, owing to the difficulty of the determination. With the CO_2, about 10 percent, the loss due to 1 percent of CO means about 5 percent of the calorific value of the coal. Under the same conditions, 1 percent of CH_4 means a loss of 16 percent, and 1 percent of C_2H_4 causes a loss as great as 30 percent. These and other hydrocarbons are very likely present in many furnaces where conditions are not favorable to complete combustion. In series of tests with an increasing percent of CO, the radiation and undetermined loss generally increases accordingly, indicating that there might be unburned gases escaping undetermined.

The combustion of these gases cannot be completed without sufficient oxygen thoroughly mixed at a high temperature. In order to accomplish this the furnace and boiler should be designed so that the heat will be generated in one and absorbed by the other. Both operations cannot take place at the same time and insure complete combustion.

The difficulty of obtaining the proper conditions increases with the percent of volatile matter in the coal burned. Smoke is an indication that these losses are occurring to a greater or less extent, but a smokeless stack does not necessarily indicate complete combustion.

An internally-fired boiler is the most extreme case of violating the laws governing economical combustion with bituminous coals. It is practically impossible to prevent smoke under such circumstances, as some of the burning gases are extinguished by the lowering of temperature when the flame comes in contact with the water leg or enters the tubes.

Gas coal can be burned without smoke if the laws of combustion are properly considered and the furnace constructed so that they can be carried out.

The volatile matter is driven off from coal very rapidly after it is spread over an incandescent bed of coals. Some experiments were once made to determine the rate at which the gases were given off and the rate of generation of heat when coal was fired.

A gas coal developed 30 percent of its total heat during the first five minutes, and the volatile was reduced from 36 percent to 15 percent. A semi-bituminous coal developed 15 percent of its heat during the first five minutes, and the volatile was reduced from 20 percent to 11 percent. At the point of maximum liberation of volatile from the gas coal it was developing 1,000 B. T. U. per minute. From these data the great variation in air required for complete combustion can be realized, and it is very doubtful whether there can be sufficient oxygen present at the critical time when coal is fired intermittently. The more uniformly the coal is supplied the better the opportunity for complete combustion. One great advantage of the mechanical stoker is that it feeds the coal to the furnace continually, thereby holding the requirements for air in a constant ratio with the air supply. As none of the mechanical devices are perfect, they produce ideal conditions only to a certain extent.

Unburned Coal.—In a stationary plant this loss is confined almost entirely to the coke or partly burned coal passing into the ash pit or drawn out the fire door with the ashes and clinkers. It varies with the opening in the grate, also with the percent of ash in the coal. The higher ash coals require more slicing and more frequent cleaning, and as the loss of partially burned coal varies with the working of the fire, it would naturally be greater. Some kinds of mechanical stokers are very wasteful in this respect unless careful attention is given to the part of the grate where the ashes fall off or are dumped intermittently. This loss from a chain grate stoker amounted to 16 percent in one test. In a locomotive the partially burned coal drawn through the flues is a very great loss; in some cases it was found to exceed 20 percent of the heat value of the coal.

Radiation.—This item of the heat balance is very difficult to determine directly, and is mostly taken by difference; hence it includes any errors made in the other determinations, as well as heat absorbed by the brickwork in the case of boilers with the brick setting. The latter error is one of frequent occurrence, as most tests are made under conditions more favorable to a higher rate of combustion and higher furnace temperature than during the 40 hours previous.

Rate of Combustion.—With the same difference in draft below and above the bed of fuel the rate of combustion varies with volatile in the coal; character of coal, whether coking or not; and upon the amount and nature of ash. In a high volatile coal a large percent of its weight is driven off regardless of the flow of air through the bed of fuel. A coking coal gives less area of opening through the fuel bed. Ash that does not clinker apparently reduces the rate of combustion but little. However, if this ash fuses at a comparatively low temperature, the clinkers formed reduce the amount of air passing through the grate by reducing the effective grate area by an amount equal to the area covered by the clinker. The more plastic the clinker the greater is this reduction in the rate of combustion, which is sometimes 50 percent within 8 hours after the fire has been cleaned.

A great many smaller plants have difficulty in burning sufficient coal to keep their mill running, even with good coal. This result is usually caused by insufficient draft, as the horsepower required is beyond the capacity of the stack, or else other smoke connections have been added with no attention being given to the flow of gases.

Coal Handling.—The cost to handle coal from the cars or vessel to the furnaces varies considerably. In large plants, with coal-handling machinery and mechanical stokers, it can be handled for 18 or 20 cents per ton from barges, and 25 cents per ton from railroad cars. Where the coal is unloaded, passed and fired by hand, it costs from 40 cents per ton to as high as $1.25 in fair-sized plants.

A contributor to the *Railroad Gazette* draws the following conclusions regarding piece work from the experiences of an important group of railroads. It gives the officers far better control of their men; it increases the efficiency of shop output and is economical; it makes money for the workman; union leaders are usually hostile to the introduction of it; it cannot be introduced successfully by placard, but must be worked out by diplomacy and intelligent co-operation with the workmen. The piece prices should not be changed after having once been established, and the men should be allowed to earn all they can.

Bracing Flat Surfaces in Steam Boilers.

Stays and braces are used for the purpose of securing various parts of a steam boiler, so that deformation will not take place under pressure. Some shapes, however, are so formed that the pressure instead of causing distortion, tends to maintain the desired shape. Under such circumstances bracing is not required.

DEFORMATION.

Mention has been made of deformation, and a question may arise as to what deformation is and what are the direct causes of it. Deformation means that the sheet has assumed a shape other than is natural or intended. Thus, if the fire-box side sheet, Fig. 1, bulges out, as shown in Fig. 2, deformation of the plate has taken place.

In boiler work, deformation may be attributed to two causes. First, for a given thickness of plate at a certain pressure the pitch of stays may be so excessive that the plate is not properly secured to resist the load, and, therefore, it bends or bulges out. Second, foreign matter may become attached to the plate so that the water will only indirectly cool it; then the plate becomes overheated, loses its strength and deformation sets in.

It is a common occurrence to see the crown sheet of a locomotive boiler bulged down between the crown bars or crown bolts. The boiler washer, backed by the foreman boiler maker, will swear that the boiler was thoroughly washed, and that the deformation must be attributed to some cause other than sediment on the plate. The fact remains, however, that sediment prevented the water from directly reaching the plate.

Bulging of crown sheets is particularly liable to occur when there is only a small water space between the crown bar and crown sheet. This space in time is gradually closed in, reducing the amount of water space; the amount of sediment increases, and gives warning of its presence by causing the sheet to bulge. Bulging from the same cause may occur on flat crown sheets stayed with crown bolts that extend to the roof sheet.

WASHOUT HOLES AND THEIR LOCATION.

Sizing up a boiler, as to the number and location of washout holes, it often appears, before the boiler is placed in the frames, that every reasonable provision for washing has been made; but as the building of the engine progresses it is found that what was figured on as a certainty is in many respects an impossibility; that is, the newly-erected parts interfere, the washout plugs being so located that they can be removed only with great difficulty, and washing the boiler is even more difficult.

Assuming that no miscalculations in the location and number of washout holes are made there is yet to be considered the indifference of the boiler washer, who expects to wash the boiler thoroughly by removing only about a quarter of the plugs. The writer has found in place boiler plugs that should have been removed easily, but which had been in one position so long that they had to be drilled out. It would not be just to place all the blame on the poor boiler washer, as he feels, no doubt, that since he gets a large amount of mud out of each boiler, most, if not all, of the foreign matter is actually removed; again, he may be called upon to wash so many boilers within a given time that he really cannot do justice to each boiler. Therefore, the boilers get "a lick and a promise" to do better the next time.

The question as to how the cause of deformation may be attributed to the presence of sediment when the boiler has, beyond any question of doubt, been washed out thoroughly may be answered by stating that when water injected into the boiler is heated to or above 212 degrees F., and is converted into steam, the impurities are of necessity left behind when the water undergoes this change of form. Regardless of all the pains taken to prevent it, the impurities extracted from the water will, to some extent, adhere to the sheets. Part of these impurities float on the surface of the water and are

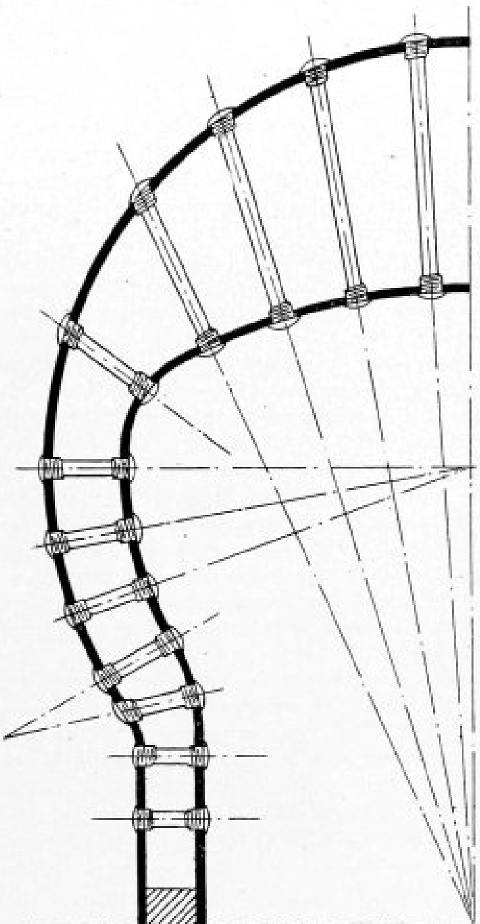


FIG. 1.

forced on the sheets by quickly drawing off the water. As the water lowers the impurities settle on the sheets and quickly dry there, so that when the boiler is washed the scale thus formed is non-removable. Coat upon coat is added to the scale until at last its presence is made known by deformation of the plates. It is no secret that this scale decreases the steaming qualities of the boiler, which then consumes more fuel with less service.

To be washed properly the boiler should be allowed to get stone cold before the water is released. Then wash out thoroughly. While washing will not entirely remove all the sediment, it will go a long way towards preventing the scale from adhering to the sheets.

EFFECTS OF DEFORMATION ON THE STAYS.

Several ideas have been advanced from time to time as to why the plate pulls away from the stay. Some attribute this to the threads and insufficient stay-bolt head, but I venture to say that not one instance has been known where the stays pulled away from the plates unless deformation of the plates was first in evidence. Of course, this is assuming that the stay-bolt and sheet have good threads, the stay-bolt being fitted to the hole properly and riveted over, as should be done in every case.

The moment the plates assume any shape other than they should have, then an action takes place that destroys the holding qualities of the thread of the stay-bolt. Were deformation to set in the threads of the stay-bolt on the inner (water) side would not hug closely to the threads in the sheet. Thus the outer threads would have an additional load, which, if too great, would result in the sheet freeing itself from the stay-bolt by stripping the outer threads and pulling off the stay-bolt head.

Were excessive pressure to be placed upon the area supported by the stays and deformation was not in evidence, the load, if sufficient, would break the stay-bolt. Thus we are brought to the question, why is it that in the face of tests which have shown what factors of safety should be employed excessive stresses are still allowed? The general impression seems to be that a factor of safety of five is quite sufficient for all purposes. It is true that this factor is sufficient for some parts, but it cannot be made a standard for every part.

Threaded stays are, by most authorities, allowed a working stress of but 6,000 pounds per inch of sectional area, yet this is considered by the factor-of-five people as an inconsistent

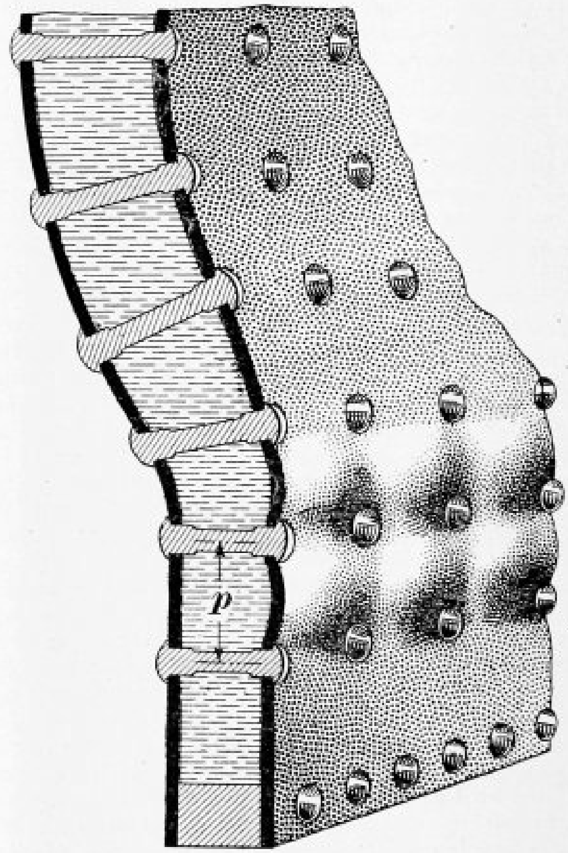


FIG. 2.

and arbitrary figure. In championing their opinion they advance the point that were a boiler of ½-inch plate, of 60,000 pounds tensile strength, made with a 90 percent riveted joint, having 1-inch rivet holes, 10-inch maximum pitch, the lowest efficiency would be at the maximum pitch. Then, if a factor of five were allowed, the allowable working stress per sectional inch on the net section of plate of the riveted joint would be 12,000 pounds. Therefore, if 12,000 pounds is the allowable stress on the boiler plate, why is the stay-bolt value rated at only 50 percent of the plate? At first thought there would appear to be some logic in the argument above suggested, but it must be admitted that stay-bolts have thrown upon them work far more difficult than is done by the plate, and consequently they require a larger factor of safety. In addition to resisting the tensile stress, a rigid stay has a vibratory or transverse stress to withstand. Again, the area of a stay is so small that if it is reduced the least particle by corrosion a large percentage of its area is lost, causing a rapid reduction in its holding power. The vibratory stress, due to expansion and contraction, will in time fracture the bolt. The fracture will not occur all at one time, but once the stay gets started it soon breaks clear through.

A tell-tale hole is drilled into the stay to act as an alarm, giving warning that the stay is broken. *Many replace this broken stay by putting in and riveting over a wire nail in the tell-tale hole,* remarking to themselves in an undertone, "*A dead man tells no tales.*"

PURPOSE OF HEAD AND NUTS ON STAYS.

The question, "What is the head on the stay-bolt for?" was asked at the 1907 convention of the International Master Boiler Makers' Association.

(1) In discussing this question it has been pointed out that the head was for the purpose of having sufficient metal extend beyond the furnace sheet so the stay could be driven, causing the bolt to swell and fit more tightly to the threads of the sheet than they did when the stay was merely screwed in.

(2) It has been further stated that the head assisted in retaining the factor of safety.

(3) Some have thought the "head does not make much difference."

No doubt if a thorough analysis of this question is made some very important facts will be brought out. It must be admitted that there is truth in the first statement. It is a well-known fact that in order to make the bolts fit tightly to the threads of the furnace sheet the stay must be driven.

It is further, a positive fact that too large a head prevents the bolt from upsetting in the sheet. A large head is undesirable, because the head of the stay is only indirectly cooled by the water in the water space. The head cannot receive the same cooling as the plate, which is directly cooled by the water. On these grounds it is practicable to use small heads. Considering the second statement, the question might be raised as to how the head retains the factor of safety. Whether or not it does depends materially on how and where the stay-bolt is applied. Were we to understand that the head increases the factor of safety of the body of the bolt, we should have a wrong conception, but it is a fact that the head does assist the threads in the sheet, and their combined strength is greater than the strength of the threads only.

If the threads of the stay have sufficient resistance, so that their holding capacity is in excess of the ultimate strength of the stay, then the threads do not need any assistance. The strength of the threads will naturally depend on the number of threads per inch as well as on their depth. Ordinarily the majority consider that a stay cut either with a United States Standard or Sharp V-thread has the same ultimate resistance. This, however, is not a fact. The diameter of any bolt must be figured from the root of the thread. The diameter of an inch United States threaded bolt is equal to $1 - .10825 = .89175$ inch, while the diameter of an inch Sharp V-threaded bolt is equal to $1 - .14433 = .85567$ inch, making a difference in diameter of .03608 inch.

Other than for the purposes already set forth, the head serves to prevent the deformation of the plate. While this assistance from stays screwed in and riveted over may be of such little significance that no consideration is given it, the fact remains, however, that heads are put on crown bolts for the benefit of the crown sheet. Likewise, in marine boilers, nuts are applied to stays and stay tubes so as to protect the plate from deformation. The head adds nothing to the ultimate strength of the stay, but it does assist the threads of the stays, also keeping the plate between the stays from bulging.

All radial, crown and side stays should strike the surface they support at right angles, this being accomplished by having the stays radiating towards the vertices from which the curves of the furnace sheet are drawn, as shown in Fig. 1.

In case the crown sheet is higher in front than in the rear the bolt should be at right angles to the crown sheet and not to the roof sheet.

Mileage of a Locomotive.*

Its Relation to Cost of Shop and Running Repairs—Does, it Pay to Overhaul an Engine That Will Give but 90 Days' Flue or Fire-box Service?—Who Should Determine When to Shop an Engine and Who Should Furnish the Work Report?

"Mileage of a locomotive, its relation to cost of shop and running repairs," is in my opinion a subject which should not be slighted, for in doing so it will probably give a wrong impression, as all the details of shop schedule would have to be gone through, with its expenses in relation to engine mileage. The mileage of engines in different class of service and in different localities should be considered in the total mileage expected. The cost of shop and running repairs should be handled as economically as possible. The different class of repairs are to be considered in shopping an engine: light repairs should be such that will cost for labor and material from $50 to $400, heavy repairs from $400 to $1,000, and general repairs from $1,000 up. Gangs should be organized with foremen in charge of each to handle the different classes of work. Also a floating or extra gang, which could be used to assist in forcing along work which was behind in the schedule, or to take men from to fill out where any were absent in other gangs. There is always sufficient work in shops which this extra gang could be used on when not doing as above mentioned. The work and the number of men in the different gangs should be so planned that one gang would not have more work to do than would allow them to keep up with the schedule as laid out. The work at the machines should likewise be so planned. If all the details of organization are not closely watched the cost of output will invariably increase. In case of running repairs the reports of engineers and inspectors should be closely watched, and all classes of repairs be made promptly, as neglect of this class of work invariably leads to more serious defects and is consequently more expensive. Also the keeping of running repairs up in good shape will increase the life of an engine and lengthen the time between shoppings.

"Does it pay to overhaul an engine that will give but 90 days' flue or fire-box service? How could this be handled?" It would not pay to overhaul an engine that will give but 90 days' service of flue or fire-box. I think the conditions at point of shopping, also the size of power to be overhauled, should govern this. If there were local or branch runs where this power could be used for 90 days or the power could be used in yard service for that period, this should be done; if the conditions as mentioned do not exist, then I believe it would be a wise move to repair flues or fire-box at the time of machinery overhauling.

"Who should determine when to shop an engine? And who should furnish work report?" The mileage made by engines should, to a great extent, govern the shopping, but

* From a report read by G. E. Bronson, C. R. I. & P. Ry., before the General Foremen's Convention, Chicago, May, 1908.

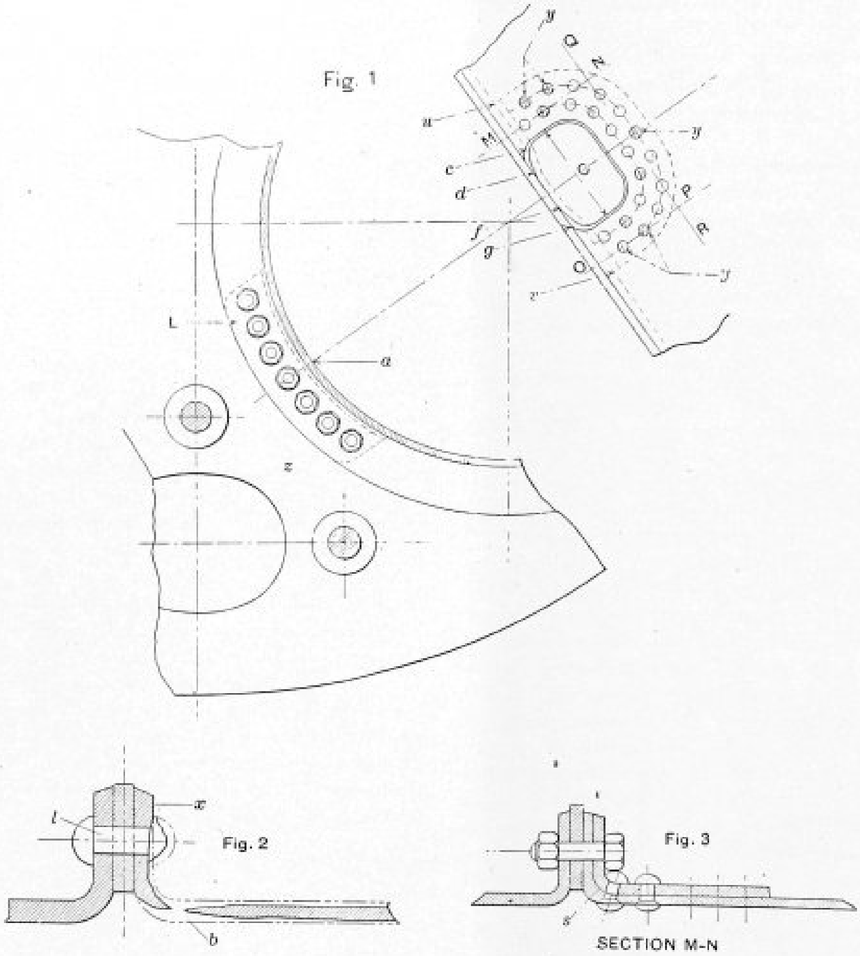
in cases where engines have not made their allotted mileage and are unfit for service, continually having failures on the road, then the general foreman and road foreman of equipment should take these cases up with their master mechanic, stating the facts. The work reports should be furnished by the engineer who runs the engine, if regularly assigned to this engine, by the engine inspector, round-house foreman and road foreman of equipment. If engine was in pool service, the work report from engineer would be done away with. Also when engine arrived at shops and was stripped, a competent inspector should go over each part thoroughly, noting wear of parts, adding his report to that of the others for the information of the general shop foreman.

same time care was necessary that the patch could be introduced into the boiler from the manhole.

(2) The hole was then trimmed to the final size, and the rivets 1, Fig. 2, were removed from the flange by cutting the heads and drilling out the bodies. Care was taken to cut the flange *x* in *d* and *f*, so that the interval *df* should be smaller than the breadth of the hole for 4 or 5 inches. The flange was also made as thin as possible at *c*, *d* and *f*, *g*. This can be done by working in the furnace.

(3) Take patterns along *MN*, *OP*, *QR* and *u*, *c*, *d*, *f*, *g*, *v* from which to make the patch.

(4) Make the patch of mild steel of 3/8 inch thickness, according to the patterns.



DAMAGED PORTION OF BOILER FURNACE AND METHOD OF MAKING REPAIRS.

Repairs to a Boiler Furnace.

This boiler was of the return fire tubular type, half cylindrical, vertically with two flat sides. There were two furnaces, strengthened with Adamson rings. One of the furnaces was broken through, as shown in *a*, Fig. 1, and *b*, Fig. 2. There was also a diminution of thickness around the hole. After examination of the mishap and considering the space available to receive a man, it was decided to fit a patch on the water side of the furnace. The repair required the following operations:

(1) To increase the hole *b* so that the thickness of the furnace in this neighborhood could be measured. This was found to be 3/8 to 7/16 inch. The size of the hole thus enlarged was then laid out on drawing paper, the size of the patch determined and the layout of rivets. The diameter of the latter was taken as 11/16 inch and the pitch about 2 inches. At the

(5) Fit the patch in place, correcting it several times if necessary so that it fits very well.

(6) Drill in the furnace some holes *y* about 1/16 inch smaller than the true diameter of rivets.

(7) Mark on the patch the holes 1 and *y*.

(8) Shift the marks of the holes *y* out of place 1/16 inch, as indicated in Fig. 4, the holes in the furnace being nearer the flanges than the holes in the patch.

(9) Drill the holes of the same diameter as in the flange.

(10) Fit the piece by bolting first with temporary bolts 1 and with two or three bolts *y*. Then tighten them hard. Put a broach in the other holes *y* with a hammer, and in this manner the holes will come fair, and a perfect fit will be secured in the angles *s*. Then put bolts in all the holes and tighten them.

(11) Drill the holes remaining in the two plates to the true diameter of the rivets.

(12) Heat the patch to redness with a blast lamp and finish the fit with a hammer.

(13) Fit bolts in the holes drilled to the true diameter of the rivets.

(14) Take out the first bolts *y* and bore these holes to the true diameter. Bore also the holes in the flanges *L*, and fit

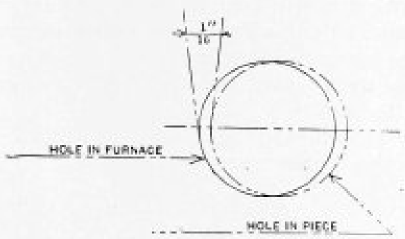


Fig. 4

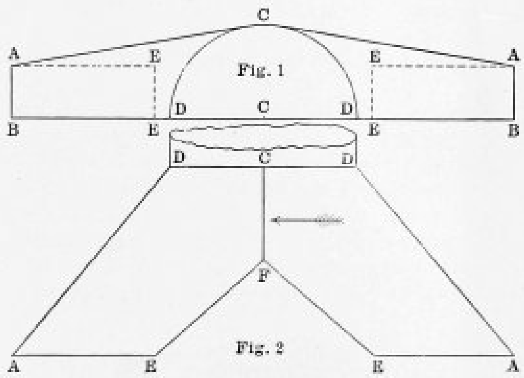
MANNER OF SHIFTING HOLES IN PATCH.

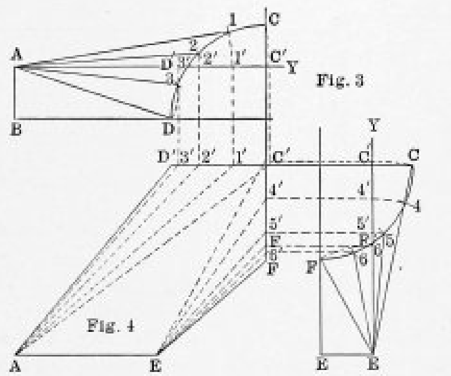
in these holes body-bound bolts. Tighten nuts with a box wrench.

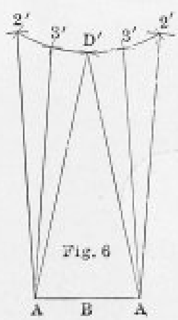
(15) Then rivet up the piece. The rivets have flat heads on the inside and are countersunk on the outside.

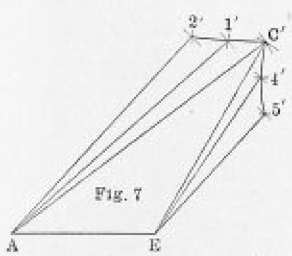
(16) Calk carefully the side of the furnace.

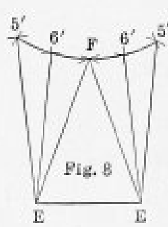
In this case the repairs were carried out in the manner above described and the hydraulic test was successfully passed.











New Method of Laying Out an Up-Take.

BY J. M. JONES.

Fig. 1 shows a half plan of two rectangular up-takes and a round pipe with the transition connections betweon them. To develop this transition piece divide it into four parts, as shown by the patterns of the side in Fig. 6, the front and back as in Fig. 7, and the throat as in Fig. 8. First in Fig. 3 draw one-half the half plan of Fig. 1. From the point *A* draw the line *A Y* of indefinite length, and parallel to *B D*. Space the quarter circle *C D* into four equal parts, and number the points of division 1, 2, 3. With *A* as a center, and using successively the distances *A C*, *A* 1, *A* 2, *A* 3 and *A D*, scribe the dotted arcs terminating in the line *A Y* at points *C'*, 1' 2', 3' and *D'*. Points 3' and *D'* in this case happen to be the same.

Draw Fig. 4, showing one-half the elevation of Fig. 2. To the right of Fig. 4 draw Fig. 5, showing a side elevation of Fig. 2, as seen when looking in the direction indicated by the arrow in Fig. 2. From *E* draw the line *E Y* of indefinite length. Space the quarter circle *C F* into four equal parts, and number the points 4, 5, 6 as shown. From *E* as a center, and using successively the distances *E C*, *E* 4, *E* 5, *E* 6 and *E F*, scribe the dotted arcs terminating in *E Y*, as shown at *C'*, 4', 5', *F'* and 6'. From *C'*, 1', 2', 3' and *D'* in Fig. 3, and from *C'*, 4', 5', 6' and *F'* in Fig. 5 project vertical and horizontal lines to the lines *D' C'* and *C' F'* of Fig. 4, and number them as shown.

To lay out the side piece shown in Fig. 6, draw the line *A B A* equal in length to twice *A B* in the plan. From the points *A* as centers, and the distances *AD'*, *A3'*, *A2'* obtained from Fig. 4, scribe the arcs *AD'*, *A3'* and *A2'*. From the intersection of the arcs *AD'* with the dividers set to the spacing of the quarter circle *C D* in Fig. 3, cut the arcs at 3' and 2' as shown. Draw the curved line 2' 2' and the lines *A2'*, *A2'* to complete the pattern. Add the necessary laps and flanges.

The pattern of the throat piece, as shown in Fig. 8, is developed by the same method as the pattern in Fig. 6, and should need no explanation. To make the pattern for the front and back, as shown in Fig. 7, draw the line *A E* equal in length to *A E* in the plan. From the points *A* and *E* as centers, and the distances *AC'*, *EC'* derived from Fig. 4, scribe arcs, cutting each other at *C'*. Also, from points *A* and *E* scribe arcs *A1'*, *A2'* to the left of *C'*, and arcs 4', 5' to the right of *C'*. With the dividers set at the length of one division of the quarter circle *C E*, cut the arcs right and left from *C'* at the points 4', 5', and also at 1', 2'. Draw the curved lines *C'2' C'5'* and the lines *A2' E5'* to complete the pattern. Add the necessary laps and flanges.

It may be observed that the curved parts shown in Figs. 3, 4 and 5 are quarters of an oblique cone and are laid out as such.

Flanging Boiler Plates.—IV.

BY FRANK B. KLEINHANS.

Round Plates.

Great progress has been made in flanging round plates. Twelve or fourteen years ago the cost of flanging such plates was double what it is to-day. It is interesting to note the evolution. At one time the sheets were clamped and the flange hammered down by hand. This, of course, was very expensive. The smaller sheets were flanged under a steam

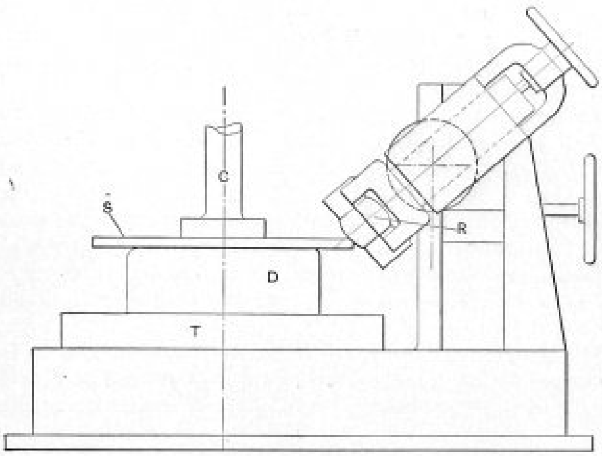


FIG. 40.—ROTARY FLANGING MACHINE.

hammer. Dies were made of suitable diameter and the sheet was heated all over. It was then hammered with light blows until it finally entered the dies. By properly arranging the dies the hammer could be used to knock the dies apart, and thus the flanged sheet could be removed.

Powerful screws have also been used. These were driven by a worm and wheel through tight and loose pulleys, driven by cross belts, for raising and lowering the screw, similar in many respects to a vertical arbor press, only larger. This, of course, if properly proportioned, can be made to flange a fair-sized plate. One disadvantage is found in holding the top die. As the screw rotates there is always a tendency for the die to get twisted, and thus it will pinch. Also it is difficult to clamp the sheet while the flanges are forced up by a

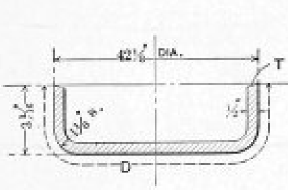


FIG. 41.

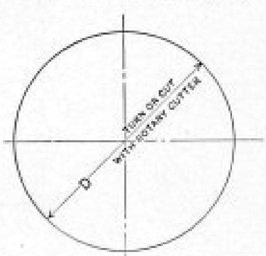


FIG. 42.

separate movement. To overcome this difficulty and also for several other reasons in the working of the material, the rotary die machine was gotten out. See Fig. 40. The sheet *S* was clamped onto the die *D* by a screw clamp *C*. This held the sheet firmly in place. *D* was fastened to a table *T*, which was made to rotate in a manner similar to a boring machine table. As the sheet was thus carried around with the die and table, a roller *R* was brought to bear on the outer surface. This roller, with its housing, was carried by a heavy frame and rotated in a circle. The motion was under the control of the operator. As the plate rotated the roller was brought down gradually on the outer surface. The metal would gradually yield, and as the flange was being formed the roller was made to follow on after it until the flange was rolled in tight against the die. A number of strong features are claimed for this machine, the principal ones being that only one die is necessary, and that the material is not injured in flanging, as the operation is similar to the rolling of the plate at the mills.

The next method is flanging by hydraulic pressure. This is the method most widely used in the shop to-day. The sheet is first clamped by one plunger, and then a separate plunger furnishes the pressure which is necessary to force the metal of the flange back against the die. This latter operation is

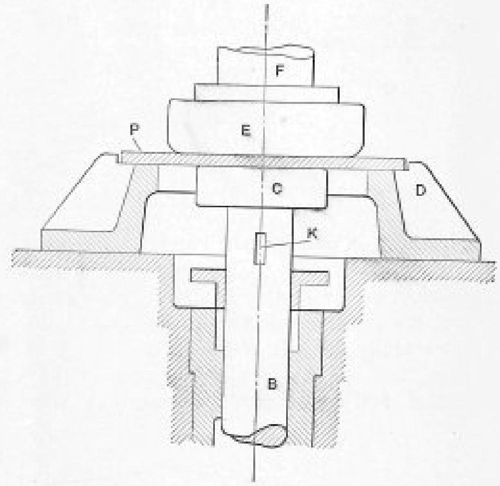


FIG. 43.—METHOD OF CLAMPING SHEET IN FOUR-COLUMN PRESS.

done very slowly, in fact as much as a minute may be consumed in turning the flange back in position. In this connection it might be mentioned that this is a good thing as long as the metal does not get chilled while the flanging operation is still going on. This slow movement gives the metal a chance to upset. This does not amount to so much on large diameters and thin plates, but with thick plates and small diameters this upsetting of the metal is quite an obstacle. Indeed, it is

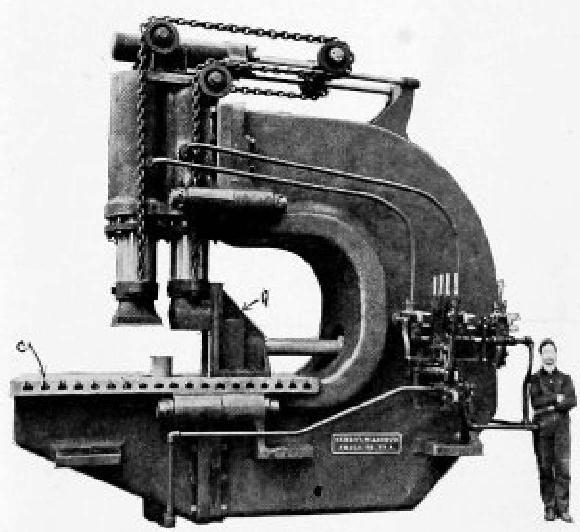


FIG. 44.—SECTIONAL FLANGING MACHINE.

almost impossible to make a perfect job of the outer surface of the flange. The metal will "bunch" in spite of all that can be done. The outside diameter is therefore more or less irregular, and it is best to mount the flange on a boring mill and take a cut off to true it up. The sheet is usually made an extra 1/16 inch thicker for this purpose. This thickness, together with the increased thickness due to upsetting, is enough to true up nicely and give sufficient strength. At the same time the edge *T,* Fig. 41, is trimmed off at an angle for calking.

The front tube sheet of a locomotive boiler furnishes one of the simplest cases of a round flanged plate. The sheet is

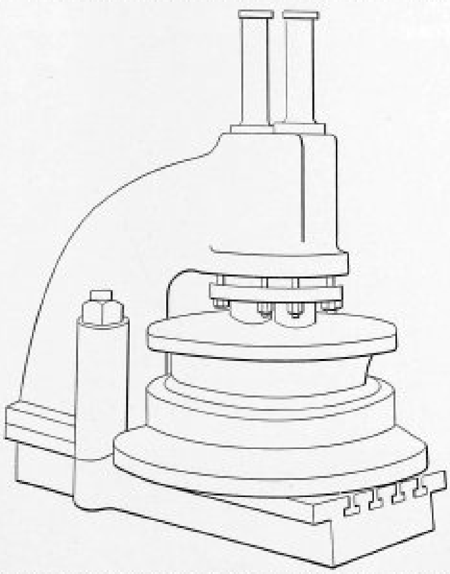


FIG. 45.—CIRCULAR DIE IN PLACE ON SECTIONAL MACHINE.

about ½ inch thick and of fairly good diameter. The flange is not so deep as to make it difficult to close in against the die; and since the diameter is large there is not so much upsetting of the metal.

Fig. 41 shows a front tube sheet which is 42⅞ inches diameter with a 3 1/16-inch flange ½ inch thick. The neutral

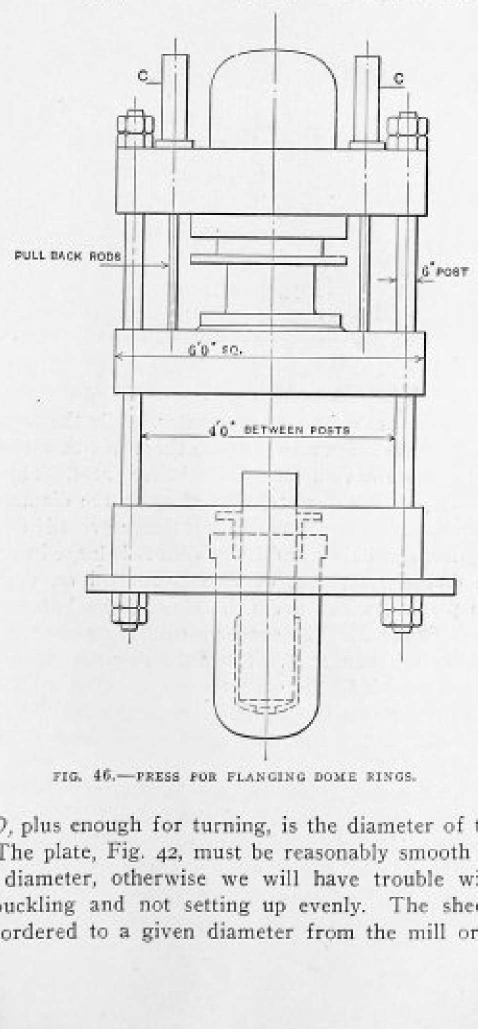


FIG. 46.—PRESS FOR FLANGING DOME RINGS.

length *D,* plus enough for turning, is the diameter of the flat plate. The plate, Fig. 42, must be reasonably smooth on the outside diameter, otherwise we will have trouble with the flange buckling and not setting up evenly. The sheets are usually ordered to a given diameter from the mill or warehouses, where they are cut to the proper diameter by rotary shears. If the sheet must be cut from stock plate to be flanged at short notice, the metal should be sheared off on the outside of the circle or punched away with a cutting punch. If the surface is not reasonably smooth a rough cut should be taken off on a boring mill.

The sheet has now been prepared by truing up the outer edge and by punching the tube holes or rivet holes for staying. It is next heated to the proper temperature for flanging,

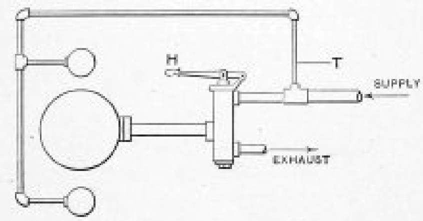


FIG. 47.—INCORRECT ARRANGEMENT OF PIPING FOR FLANGING PRESS.

and is placed on the universal or four-column flanging machine, as shown in Fig. 43. *C* is the clamping head, which is attached to the bottom plunger *B* by a key *K,* as shown, or by a dovetail slot or a taper key, or some other suitable means. The bottom die *D* is clamped to the bed of the machine, while the top die *E* is fastened in any convenient manner to the top plunger *F.* The bottom plunger is now brought up until the top of *C* is in line with the top of the die *D.* The plate *P* is then placed in position, after which the top plunger *F* is lowered to within a ½ inch or so of the plate, and then the water pressure is turned on, and the bottom plunger *B* and the sheet are clamped firmly between *C* and *E.* The plunger *F* is considerably larger than *B* and as the water is turned on the top plunger *F* forces *E* down and pushes the plate into the

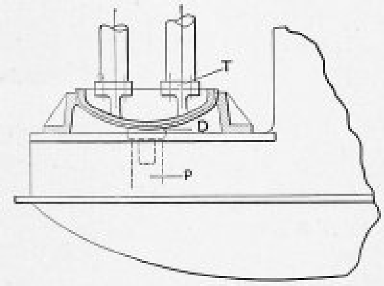


FIG. 48.—DIES FOR DISHING ROUND SHEET.

bottom die. The bottom plunger *B* keeps the plate from bulging in the center, and thus the flange is gradually forced up against the sides of *E.* When the top edge of the flange is about to disappear in the bottom die *F* is returned, and *B* forces the plate out of the bottom die.

Many shops nowadays are equipped with a sectional flanging machine, and these can readily be fitted up with dies for flanging round plates. Fig. 44 shows one of these machines, and it will be seen that they are rigged up with two upper vertical plungers, one bottom vertical plunger and a horizontal plunger. This figure illustrates a very large machine, and the

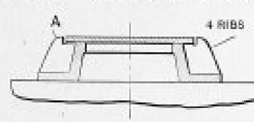


FIG. 49.

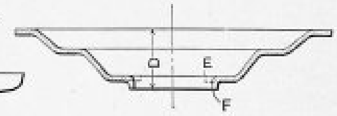


FIG. 50.

vertical plunger draws back and is made to pull at right angles, in order to clear the traveling crane. The cored *T* slots *C* make it easy to invert bolts for clamping the bottom die.

Fig. 45 shows a persepctive view of one of these dies in place, showing the method of attaching both plungers to the same die. In this case the plungers are recessed into the die and are securely attached to it by key bolts. The drawback cylinder in this case is attached direct. In this connection it might be mentioned that the drawback cylinders are internally packed. Now, in an argument you might prove that this arrangement is just as good as an externally packed cylinder, but the constant tendency in the boiler shop is to do away with internal packing as much as possible and substitute outside packing instead.

Another type of machine which can be seen in some boiler shops and which is used largely for flanging dome rings, dome casings, tube sheets, etc., is shown in Fig. 46. This machine has a capacity of 125 tons and a bottom plunger of 50 tons capacity. It is 48 inches between posts on each side, and has top and bottom plates 6 feet square, with cored tee slots for holding on the dies. This machine cannot be used for the variety of work that a sectional flanging machine can be used for, but where a large number of round plates are to be flanged this type of machine has a great many features

Thus far we have dealt with flat round sheets with the flanges bent at right angles. There are other round plates required for various parts of a boiler, and therefore we will take a few examples of these sheets. In Fig. 48 we have a round plate with a dished end. This is a very difficult sheet to flange except by hydraulic machinery. *P* is the bottom plunger, which carries a plain, flat die *D*. This need not be very large in diameter in proportion to the sheet. The plate is set central on the annular die by some convenient means, as, for instance, lug *A*, Fig. 49, or an extension of the lug on a line with the top may be used with pins to center the plate. Of course there is an endless number of ways for doing this, but the things to be governed by are simplicity and effectiveness. The top die *T*, Fig. 48, is fastened to the two vertical plungers of a sectional flanging machine. If this sheet is thick there will be considerable bunching up of the metal, and this must be slowly drawn out as it is being pushed down through the bottom die. It is often a good plan to have a stop arranged on the top die so that the flanged sheet canot be pushed down too far. If this occurs when the sheet is being forced

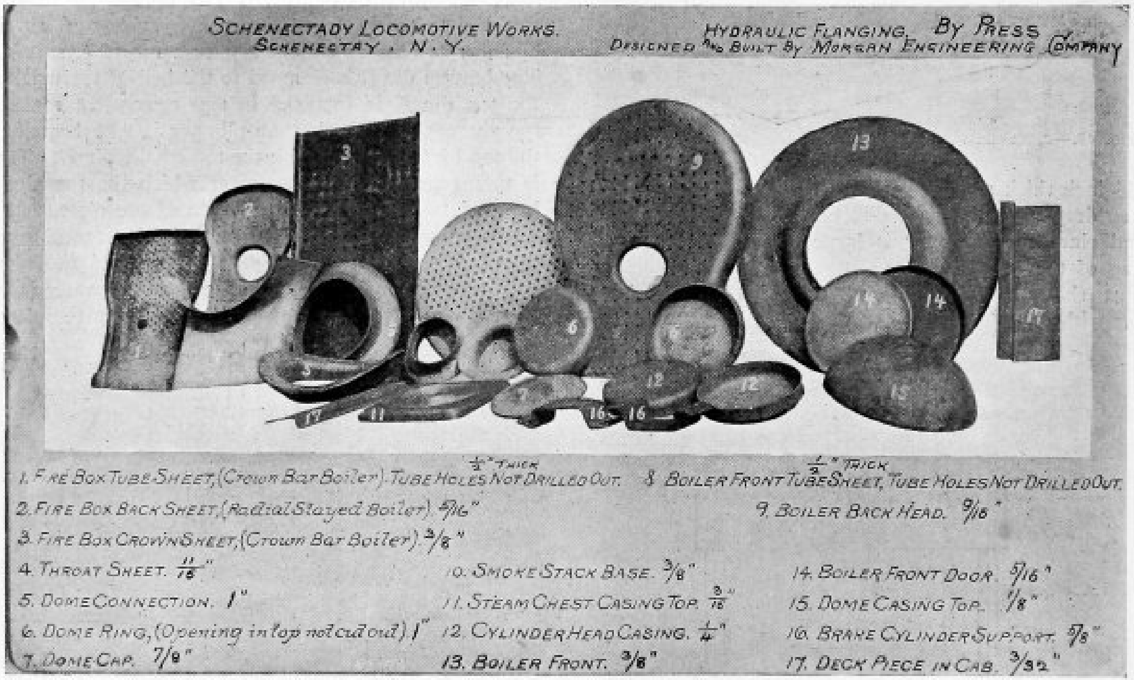


FIG. 51.

to commend itself. The dies have good, large faces to rest on, both on top and on the bottom, also they cannot tip over, as they are apt to do when attached to plungers. The drawback cylinders are shown at *c* and *c*.

In piping up for this machine several precautions should be taken. First, the valve should be 1½ inches, so that the plungers will act reasonably fast. Also, the pipe line should be of good size if it is of any great length, as the water pressure and flow will be cut down by a small pipe. Fig. 47 shows a condition of piping that is sure to give trouble. When the valve handle *H* is thrown open the water rushes by the drawback-cylinder pipe *T*, due to the fact that there is no resistance for the main plunger to overcome. This will reduce the pressure in the drawback cylinder, and the result will be that the top platen will fall down on the sheet without warning and cause trouble. The thing to do is to put a plunger connection between *T* and the valve, and insert a diaphragm with a smaller hole than the diameter of the pipe. A little experimenting will tell whether the hole is too large or too small.

out it will be pushed up in the center, while the outside edge will stick to the sides, and thus the sheet will be spoiled.

In Fig. 50 we have a locomotive boiler front. This is made of from ⅜ to ½-inch plate, depending on the diameter. This must be flanged in the four-column flange press if the sheet is for any fair size boiler, and if the dish *D* is large in proportion to the diameter. A set of dies is carried on the top and bottom platens, which press the sheet down but do not curl the inner flange *F*. The sheet up to this stage is straight on the inside, as shown at *E*. When the dies are down solid the flange is set back by the use of a top cylinder, a spherical die being forced down through a hole in the bottom die. The edge of this flange and also the outer diameters are afterwards turned off.

One of the sheets can be seen in Fig. 51, No. 13. No. 8 shows a front tube sheet. All the holes have been punched ¾ to 1 inch before flanging. In setting this sheet care must be taken to get it central, otherwise the tubes will not come out right. Various other round sheets are shown and the places where they are used are marked.

In Fig. 52 we have a four-column press rigged up for flanging round plates. A 72-inch by ½-inch plate is suspended from the crane, and a large number of male and female dies are shown piled up in the foreground.

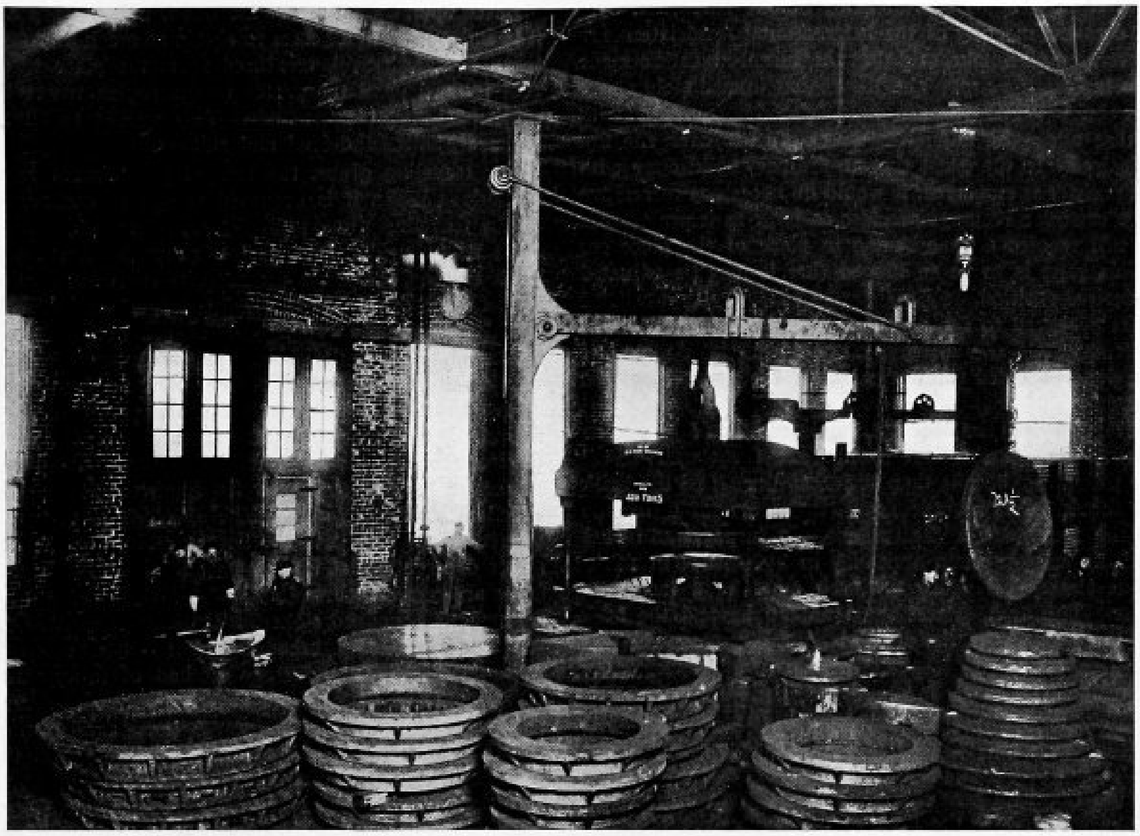


FIG. 52.—FOUR-COLUMN PRESS INSTALLED IN A BOILER SHOP FOR FLANGING ROUND PLATES.

Smoke Prevention.

The question of smoke prevention must receive more attention from boiler manufacturers and engineers in the future than it has in the past. Not only is a smoky atmosphere damaging to health, but the accumulation of soot on buildings, trees and other exposed objects contains sufficient sulphuric acid to have a serious effect on metal, plant life and various textures of wearing apparel and household furnishings.

Smoke is only produced with certain kinds of fuel, and the amount produced may be greatly decreased by properly designing the furnace in which it is burned to secure complete combustion of the fuel. The actual increased economy in the consumption of fuel obtained with smokeless combustion is not very great, although in some cases it has been claimed that 10 or 15 percent has been saved.

For practical purposes coal may be said to consist of a mixture of solid carbon and gaseous hydrocarbons. It is the hydrocarbon gases which cause the difficulty in burning coal without smoke. The percentage of these gases varies from about 6 percent in anthracite to 35 or 40 percent in bituminous coal. Therefore, bituminous coal is the chief offender as a smoke producer.

The gradual heating of fresh bituminous coal on the grate in a steam plant drives off the volatile hydrocarbon gases, which, if maintained at a sufficiently high temperature and mixed with a proper amount of air, will burn with a long, yellow flame, giving practically no smoke. If, however, the temperature in the furnace is lowered so that they will not ignite, or if sufficient air is not brought in contact with them to support combustion, these gases will, of course, pass up the stack unconsumed. If there is plenty of air admitted, but the temperature is allowed to drop, the gases do not liberate soot, whereas, if sufficient air is not admitted to support combustion, only partial combustion will occur, and solid articles of carbon will separate, which will later appear in the form of soot, causing thick black smoke. Therefore, to obtain smokeless combustion the principal requirement is that there shall be sufficient air admitted to the furnace and thoroughly mixed with the distilled gases at a temperature sufficiently high to cause their ignition.

The actual amount of heat lost in the carbon which appears in smoke in the form of soot is very small, and has little effect on the economy of the plant. The loss of economy occurs in the non-combustion of the hydrocarbon gases, which when burned will produce about 36 percent of the heat units contained in the coal. Furthermore, the deposits of soot on boiler plates and tubes very greatly affect the transmission of heat from the gases to the water in the boiler, so that the thermal efficiency of the boiler is greatly lowered.

Two things may be done to prevent smoke. The first is to design the furnace so that the hydrocarbon gases distilled from the coal will not immediately strike the cool surface of the boiler, and thus have their temperature lowered below the ignition point; providing at the same time for the admission of a proper amount of air heated, if possible, to support the combustion of these gases. The second is the proper firing of the fuel in the furnace. In small plants, where it may not be considered economical to install automatic stokers, this can only be accomplished by the employment of carefully trained firemen, since it is possible by properly firing a well-designed furnace to practically eliminate the smoke. In large plants, however, the use of mechanical stokers provides a means of controlling the supply of coal and air so that complete combustion can be obtained.

For the setting of return tubular boilers to obtain smokeless combustion, Mr. Robert H. Kuss, chief assistant smoke inspector of the city of Chicago, in describing the requirements of the Chicago Department of Smoke Inspection System at a recent meeting of the International Association for the Prevention of Smoke, said that the furnace must be made so as to inclose the grate and the region immediately above it in firebrick. The furnace must also be equipped with doors that allow the admission of excess air over the fire when desired. In the event that an ordinary solid door with a small register is employed, it would be necessary to remove from the casting a rectangular piece as large as is practicable, and it will require a vane swung in place of the piece cut out. This vane is to be so hinged that it may be adjusted in any desired position.

If it is proposed to use a system of automatic jets, steam and automatic air admission in place of special doors, this may be done provided the design meets the approval of the department.

The firebrick over the door opening liners should be arched and sprung free of the liner itself. The front wall of the furnace should not be less than 18 inches thick, and the brick therein should be first-grade firebrick throughout up to the line of the main arch of the furnace. In furnaces 48 inches in width or less the main arch may be 4½ inches in thickness, but above this width the arch must be 9 inches in thickness. The arch system must extend beyond the back face of the bridge wall, the distance depending upon the size of the furnace.

The bridge wall must be made with first-grade firebrick, solid above the grate line and faced not less than 9 inches thick below the grate line extending to the combustion chamber floor. The lining of the furnace proper, meaning the side walls below the main arch extending to the grates in front of the bridge wall and to the floor of the combustion chamber behind the bridge wall, shall be 9 inches in first-grade firebrick.

Above the main arch of the furnace and behind the furnace proper in the combustion chamber, the lining may be 4½ inches in first-grade firebrick, with headers every fifth row, but must extend to the combustion chamber floor. The combustion chamber floor is to be paved with firebrick set on edge. but this firebrick may be seconds or old first-grade firebrick previously used.

Blow-off protection is not regulated in any respect by the department of smoke inspection, this matter being left to the department of steam boiler inspection.

In order to secure the main arch and prevent its falling down, it is necessary to insert into the side walls either I-beams or channels with the metal exposed to the outside, these beams to be held in place by the vertical buck stays. The air space in the region in which the thrust of the arch comes should not be employed.

Attention is here called to the way in which the arch meeting the rear tube sheet should be constructed. Any exposed metal system should be rejected. The Hartford method of springing the arch from side to side is preferable to the system of springing the arch from the rear setting wall to the tube sheet. The selection of a boiler with the manhole in the rear tube sheet will not allow the use of the Hartford arch, and this point should be borne in mind. Where, in the judgment of the department, it is advisable to employ a deflection arch behind the main arch, such will be insisted upon.

It is not within the province of the smoke department to insist that furnaces shall be extended in front of the boiler lines, but it recommends that in all cases where it is possible to do this the extension furnace should be adopted. In the case of extension furnaces an insulated arch must be employed. Where some form of automatic fuel feed is used a deflection arch behind the main arch is not always insisted upon, though it is seen to that this may be inserted afterward in case of an unsatisfactory performance without.

Based upon the advice of the Board of Advisory Engineers, it is endeavored in all cases to obtain as much as 7 feet of distance for gas travel, measured from the place where fresh fuel is fired upon the grates to the region where the gases reach heat-absorbing surface. This applies to all forms of furnaces, both hand-fired and stokers.

For traveling grates the following minimum requirement is made: When it is proposed to use a mechanical stoker of the traveling grate type, the minimum which the department will consider favorably is an arrangement where the brick arching above the grate or its equivalent extends to a vertical line drawn from the front face of the bridge wall. The height of the bridge wall should not be less than 16 inches, more being desirable. The area over the bridge wall should not be less than 30 percent of the effective grate area.

Mechanical fuel feeders must always be equipped with arches. Scotch marine boilers are always equipped with extension furnaces, and the minimum apparatus found to be successful has been a gravity-fed furnace, and then only with excellent draft facilities. The under-feed stoker has answered fairly well with the Scotch marine in the few cases under observation, at least during the periods when the furnaces are running normally.

For double-inclined stokers it is desirable to have extension furnaces in all cases, because then it is not necessary to depend upon the unsatisfactory method of firing through the front magazine door, which necessitates pushing the coal to the back part of the magazine. A great deal of the trouble occurring with this form of stoker is attributable to this cause alone, because the service is intermittent.

In the municipal regulation of smoke it is necessary to have some means of grading the density of the smoke, in order that heavy black smoke may be definitely prohibited for more than a few minutes during the day. For the purpose of specifying the amount of smoke which may be allowed various scales have been projected, the most common of which consists of charts of various tints, which can be compared directly with the smoke issuing from the stack. Prof. Ringelmann has proposed a chart in which different intensities of smoke are indicated by an arrangement of black lines on white paper. The lines are of various thicknesses, and so arranged that the area of the white spaces between the lines is varied. When held at a given distance from the eye these charts appear as various tints, ranging from white to black. By the use of such a chart a plot can be made showing the intensity of the smoke at stated intervals and the length of time it is emitted from the stack. Thus a complete record of the amount of smoke produced in a stack can be obtained for any desired period.

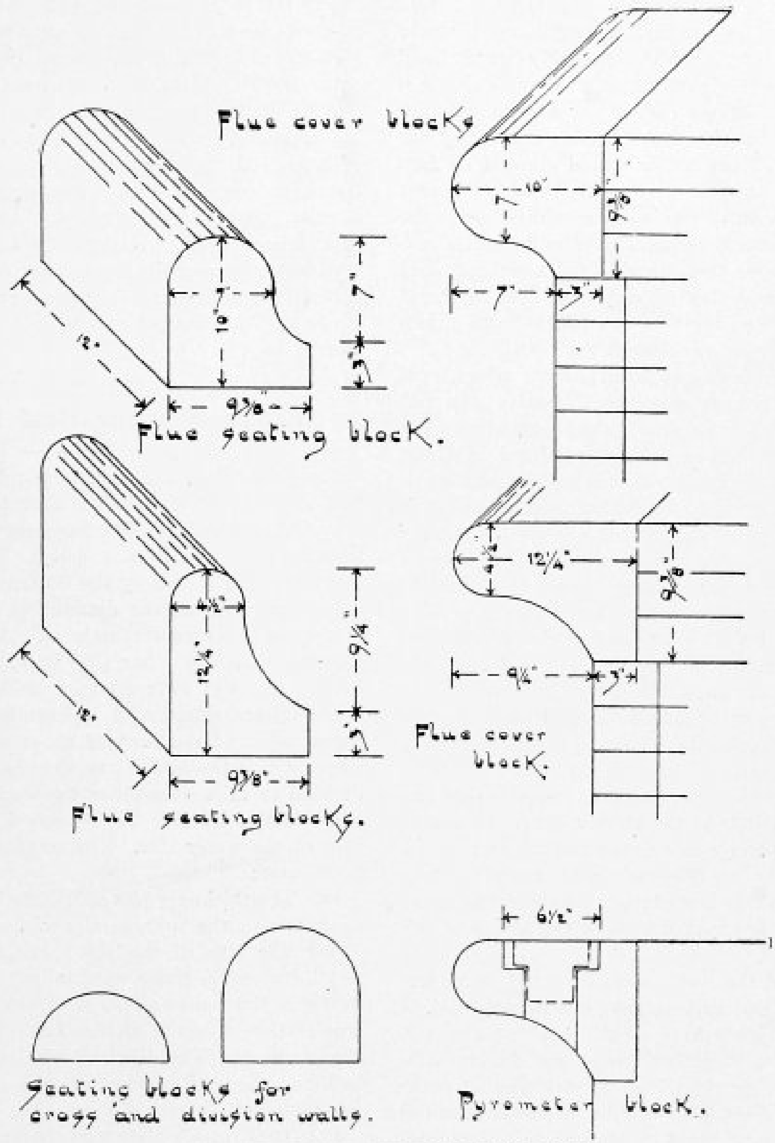
Practically the only way to eliminate smoke from the railroads is to use some kind of fuel in which the percentage of volatile hydrocarbons is low. Anthracite, coke and briquettes fulfill these requirements, but in most cases their cost is prohibitive. The conditions in a locomotive furnace are not favorable to the complete combustion of bituminous coal, and it is doubtful if they can be made so, although some devices tend to secure this result. Firebrick arches prevent the distilled hydrocarbon gases from being drawn immediately into the tubes before they have an opportunity to ignite, but brick arches have been found to be troublesome and expensive to maintain, and in a number of instances have failed to give any appreciable economy. As economy is the watchword in railroad work, little attention is likely to be given to the smoke problem by railroad officials until they are forced to do so.

Recent Improvements in Boiler-Setting in Great Britain.

Mechanical engineers in the manufacturing districts of Great Britain have so continuously devoted their attention to the improvement of the steam engine, that improvements in the construction of boilers have to a very large extent been neglected. The boiler, after all, is the source of energy and quite as important as the engine and the two ought to be considered and perfected *pari passu,* for the quantity of coal required per hour for each indicated horsepower is the measure of the waste or of the economy of the combined steam-producing and steam-using plant.

During recent years the term "economic use of steam," or the number of pounds of steam or water used per indicated horsepower, has been limited to the steam engine; it follows that a very economical steam engine may and as a matter of fact frequently is used in combination with a very faultily constructed and uneconomically working boiler. Attention has therefore been turned in England to the perfecting of the details of boiler construction and some of the results achieved are detailed below. They may be useful to American readers, engineers and works' managers interested in boiler economics and in the installation of new boilers.

Great improvements have been made in the more recent methods of testing the boiler-flue gases by means of pyrometers and by the analysis of the gases; by the use of CO_2 recorders and so on. Many prominent English boiler makers guarantee an efficiency of no less than 80 percent; although it may be more correct to state that the average is not above, if at all, over 60 percent. In many cases, in Great Britain at least (but not possibly in the United States), boilers give sufficient results as the direct consequence of the admission of an excess of fresh air into the flues; this is shown both by analysis and the CO_2 recorders. It is well known that for the perfect and complete combustion of coal 11 pounds of air are necessary per pound of coal, and that any excess of the required quantity depreciates the results obtained from the boiler; but in actual work as much as 25 pounds of air may enter the furnaces. Subject to the most favorable conditions where mechanical stoking can be applied to a battery of boilers, when the furnace temperature is high, as much as 15 pounds of air may be admitted and consumed. It follows that an admission of air not only within but also around the boiler, within the flues, as well as the furnaces, is



IMPROVED FORM OF BOILER FLUE COVER BLOCKS.

of extreme importance to all those using boilers. It is well known by practical men that (to quote an English expert) air may find an entrance at innumerable places in the envelope surrounding the boiler; the brickwork setting, therefore, assumes an importance which has hitherto not been sufficiently recognized.

An actual example taken from a large English factory may make the point clear. A boiler of the average type in general use, of the so-called Lancashire two-flued variety, specimens of which were illustrated in the February issue of THE BOILER MAKER, at page 49, say 30 feet in length and 8 feet in diameter, generally required, with reasonably good hand stoking, as much as 30 tons of coal for a 56-hour week. Assuming the coal to be 10 shillings ($2.43) per ton, an ordinary price in England, where works and collieries are rarely far apart, the annual coal bill per boiler would amount to £750 ($3,649.90), allowing for holidays. Broadly stated, the cost of a year's coal and the cost of the boiler would be about the same. An economy of coal consumption of only limited extent should, therefore, more than provide for a sinking fund for the boiler itself, as a saving of only 5 percent in round figures would amount to more than £30 ($146), and might reach nearly £40 ($194.66), or even more.

The importance of attention to cold air leakage arises from the fact that cooling action is continuously active day and night, from cold air entering the flues through numerous fine crevices, which can be and is now being obviated in Great Britain by special attention being devoted to the setting of boilers, so as totally to prevent air leakage. The result is obtained by the recent introduction and use of curvilinear seating blocks and flue covers wherever they come in contact with the boiler plates, so designed as to provide an air-tight envelope and to increase the heating surface where it is most valuable by about 2½ percent, an important point which must at once appeal to all practical men. The actual contact between the blocks and covers and the plates is reduced to a line; it follows that almost the whole of the boiler surface is exposed and that practically the whole of it can be readily seen and reliably examined.

Boiler insurance companies occasionally require that the seatings must be broken into at the riveted seams to enable the whole of the boiler surface to be seen and the flue coverings have occasionally to be removed; with more recently introduced improvements this is no longer necessary, as every portion, as stated above, is exposed both to the action of the heated gases and to view.

The seating blocks and the flue covers have the same section and are of two depths, so that they can be adjusted to both the outer and the inner laps of the boiler plates. A minimum of chipping is, therefore, necessary during construction, as a completely air-tight joint results without packing of any sort; boilers fixed by the older methods required fire-clay pointing, a clumsy method to conceal defectively designed materials.

In the case of boilers set under the old system damp frequently gets into the cross-wall causing deterioration by external corrosion; in the new system, the curved surfaces of the front cross-wall, in contact with the first ring of the shell plates, prevent that taking place altogether.

The setting is now finished level with the top of the flue cover blocks, an obvious advantage. In the older system, now superseded, the curved covering tiles required a course of bricks and a flag cover above it, as shown in the illustration published in THE BOILER MAKER, February, 1908, page 50; concealing a depth of from nine to twelve inches at least of the boiler surface on each side, an obviously clumsy piece of construction absent in the case of all more recently planned boiler installations. The principle of curvilinear surfaces in the setting of the boiler applies, of course, everywhere; over the front cross-walls, under the fire bridges, at the back end plates, the partition wall and elsewhere.

An important detail recently added to the cover blocks is the pyrometer block, usually placed at the end of each side flue of the boiler. This block is provided with a rabbeted opening, into which a stopper is fitted, which can be easily lifted to enable a pyrometer to be pushed into the flue to record the degree of heat of the gases passing along the flue towards the chimney. On odd occasions these stoppers may act as safety valves by preventing explosions in the flues should any tendency to accumulation of pressure occur.

In the illustration are shown two varieties of boiler flue cover blocks of the new improved type now used in Great Britain, with dimensions in inches; the improvement will be appreciated by readers if they will compare the illustration with the older system (now obsolete) of flue covering, illustrated on page 50 of the February number of THE BOILER MAKER. Seating blocks are also shown and blocks for cross and division walls. A section of a pyrometer block is added. The dimensions of the blocks vary for the inner and the outer boiler plates. Larger sizes are also made for both seating and cover blocks, 12 x 12 x 14¾ inches, 12 x 12 x 18½ inches and so no.

Repair of a Tug Boat Boiler Furnace.

The boiler is of the return fire-tube type with two furnaces. The diameter of the shell is 8 feet 6 inches and that of the furnaces 31½ inches. The furnaces are of the Adamson ring-type, as shown in Figs. 1 and 3. The original condition of the furnace is shown by the dotted lines. In the same drawing are also shown the diminution of thickness and the half section of the repair completed. At *c* the plate was broken through. On the other side in *f*, Fig. 2, the plate was not broken but was reduced to a thickness of from 1/16 to ⅛ inch. There was also a leak at point *d*, Fig. 3. After an examination of the furnace about the damaged locality, considering that the boiler was already 10 or 11 years old, it was decided to fit a piece over the weakened portion. This was done on the fire side, as it seemed impossible to properly fit it in on the water side. The steps in making this repair were as follows:

(1) The thickness was first tested with a hammer, in order to determine the suitable size of the patch.

(2) The size of the piece was approximately drawn and the location of rivets determined. Small holes were then drilled at the center of the rivet holes, in order to measure the true thickness of the plate. This was found to be ¼ inch or slightly more. The diameter of the rivets was taken at 11/16 inch and the pitch at 2 inches, while the thickness of the patch was 5/16 inch.

(3) The furnace plate was thoroughly scraped and cleaned.

(4) Patterns were taken along *HI, JK, MNO*.

(5) The patch was made according to the patterns, as well as possible, by fitting and correcting as many times as necessary.

(6) Holes *p* were drilled in the patch and fitted with bolts. The patch was then heated red with a blast lamp, and fitted as well as possible, especially at the flange.

(7) The size of the patch and the layout of the rivets were then finally drawn.

(8) Care was taken that the rivets situated near the flange were well drawn in, remembering that the holes were inclined, as in Fig. 3.

(9) On the right of the piece the space was too small to allow holding on for riveting, so that it was impossible to fit rivets on this side of the patch. After careful examination a line *s, t, u, v* was drawn, limiting the holes where rivets

could be driven. The other holes on the right were provided with screws, as in *x*, Fig. 3.

(10) Holes on the left were drilled at the correct diameter for the rivets. Holes on the right were drilled at a diameter smaller by 3/32 inch for screws like *x*.

(11) Holes for the screws were tapped through and through.

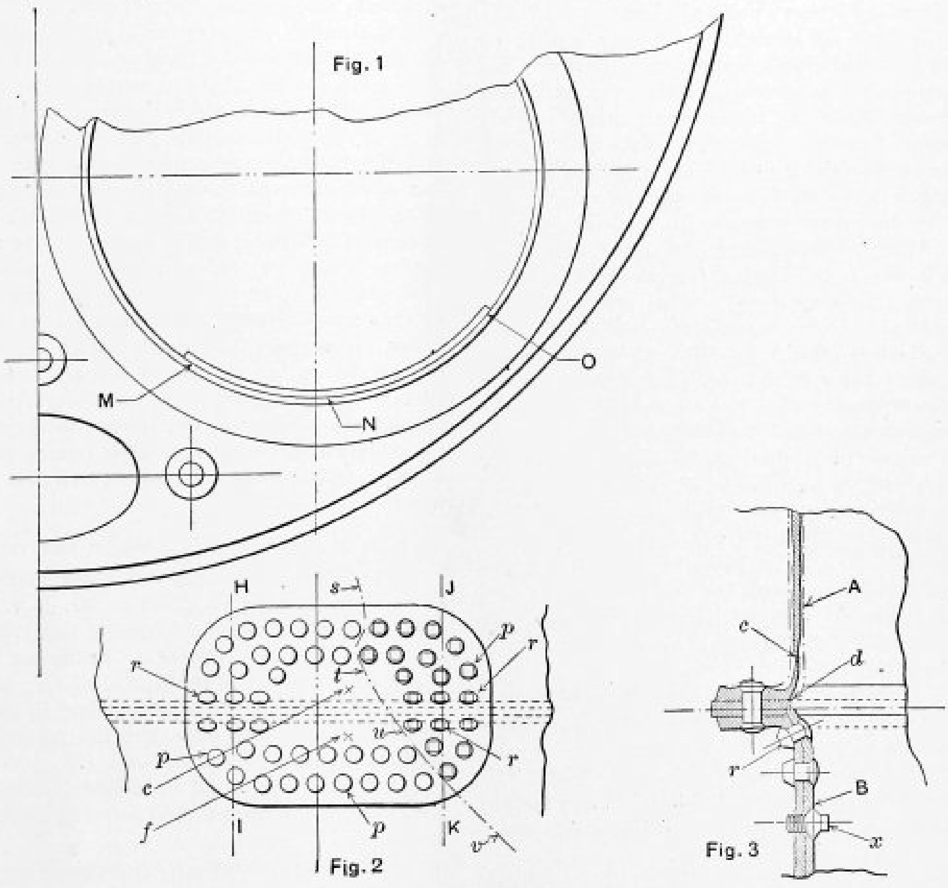
(12) All the holes on the patch were countersunk. It was found impossible to make the fit very perfect at the flange and in the groove. It was therefore decided to fit putty between the patch and furnace along the groove. This putty was made of sifted iron filings and white lead mixed with a little sulphur.

(13) The putty was laid on and the patch fitted with temporary bolts.

(14) The screws were put in the holes on the right and tightened well, also the bolts.

(15) The rivets on the left were then driven. It was possible for a man to enter the boiler to hold on.

(16) The rivets, the patch and the heads of the screws were then calked, holding on where possible on the other side.



DETAILS OF REPAIRS TO TUG BOAT BOILER FURNACE.

Fourth Annual Convention National Association of Master Sheet Metal Workers.

The fourth annual convention of the National Association of Master Sheet Metal Workers of the United States was held at the Palmer House, Chicago, Ill., on Aug. 19, 20 and 21, 1908. President Edwin L. Seabrook, of Philadelphia, Pa., presided over the meetings.

SECRETARY'S REPORT.

The annual report of W. H. Barnard, of Norfolk, Va., secretary of the association, referred to the necessity for the furnishing by manufacturers of the best possible quality of tin plate in order that the master sheet metal worker can perform his work in a satisfactory manner to the public and make his work lasting and durable. Through the efforts of the master sheet metal workers the manufacturers are now endeavoring to supply this demand, and the master sheet metal workers have, on the other hand, cheerfully paid an increased price for material. Reports from all sections indicate that only the best evidences of peace and satisfaction have come with the practical operation of the open-shop principle, to which this association has committed itself, as worthy of adoption wherever possible, because in no other way can the employer conduct his business satisfactorily. Mr. Barnard congratulated the members on the improved conditions in regard to the apprenticeship question and the establishment of night trade schools, which tend to provide a better grade of journeymen and a more abundant supply of skilled men. He also recommended the adoption of metal roofs more generally, as they are lighter and more fireproof, and more desirable from every standpoint. As metal windows secure a lower rate of insurance, so metal roofs ought to do likewise, and no efforts should be spared among insurance interests to have the more advantageous rates given where tin or metal roofs are employed in building.

PRESIDENT'S REPORT.

President Seabrook, in his report, after speaking of the improved conditions in the sheet metal trade, because of the existence and work of the National Association of Sheet Metal Workers, said that the officers had not been idle during the past year, but had been giving close attention to securing positive results for the membership. Special efforts had been made to promote the warm-air furnace, and in this work the co-operation of the manufacturers had been enlisted. The more the matter was looked into the greater appeared the necessity of extensive co-operation of all the furnace manufacturers of the country. A meeting for organization was called at New York City, May 11, 1908, to devise ways and means for promoting the furnace business, which was largely attended by manufacturers, and resulted in the formation of the Federal Furnace League, having for its object not regulating costs or selling conditions, but only the promotion of the general interests of the warm-air furnace business.

Another prominent feature of the National Association work is seen in the labors of the joint committee on tin roofing plate. Some 25,000 copies of the *Tin Roofers' Hand-Book* have been distributed, not only at home but also abroad, and the publication has aroused considerable interest. It was pointed out that a joint committee of the national association and the National Fire Protection Association, in a report embracing their classification of various roofing materials, place at the head of the list in superior fire-resisting qualities the tin roofing.

A JOBBER'S VIEW OF THE TIN ROOF QUESTION.

Mr. George G. Tanner, of Tanner & Company, Indianapolis, Ind., presented a paper on the subject of the tin roof, taking up the question from the jobber's point of view.

He said that in cases of complaints of poor quality of roofing tin he almost invariably found that the cause was not poor tin but surrounding conditions. Where the roof does not last it is generally due to extraneous matters entirely separate and distinct from the quality of the tin used.

Terne plate, or roofing tin, is made from soft steel or iron sheets, thoroughly annealed and coated with an alloy of tin and lead mixed in the proper proportions of about one part of tin to three of lead in the higher grade, and a larger proportion of lead in the lower grades. Originally the plates were made of iron, the better quality called charcoal plates, the cheaper called coke. After a while the steel plates were introduced—the Siemens-Martin process and the Bessemer process—the Siemens being a high priced and, in the early days, of much better quality than the Bessemer. When the steel plates were first introduced they brought from $1.00 to $2.00 per 14 by 20 box more than the charcoal iron plates, and finally, because of the excellence of the product, more particularly in tensile strength and finish, the charcoal iron plates were driven out of the market and were entirely superseded by the steel plates. To-day, however, there is a growing demand for charcoal iron plates for roofing purposes, and in my opinion the demand will continue to grow until the consumption of charcoal iron plates will equal, if not greatly exceed, the steel plates.

In point of finish the steel plates, as manufactured to-day, are the finest ever produced in the history of tin plate manufacture; the surface could not be improved; the tensile strength and ductility are all that could be desired. The plates are resquared and stamped and finished in the highest manner known to the art; goods properly packed and in every way are excellent.

The great question at present is as to the relative merits of steel plates and charcoal iron plates. A steel plate is more highly finished than iron, and, apparently, to the eye, is all that a plate should be. Many persons, however, incline to the belief that a genuine charcoal iron plate is more porous than the steel, and while it does not have the high finish of the steel as to surface, the iron plate being more porous, permits the coating to more thoroughly amalgamate with the iron than it does with the steel, and therefore on that account is a superior product to the steel sheet, and, personally, I am inclined to this belief. The fact that the demand for genuine charcoal iron plate is steadily growing confirms me in this belief.

We often hear about "pin holes" in tin; we really hear more about it than see it; in fact, a sheet of genuine pin-hole tin is a rarity. What are called "pin-holes" in the plates occasionally came to the surface in the old days of the manufacture of charcoal iron plates before the steel plates came into use; but after the steel plates came into use such a thing as "pin-hole" tin was rarely seen. Of course, if the sheet goes into holes or small holes, that is not always the fault called "pin holes" in tin plate. Pin holes in tin plate is where the plate goes into small holes, clearly and well defined, just about the size of the diameter of a good-size pin; after the subject being the cause of a very thorough examination and investigation in Wales some years ago, the report of a committee appointed for the purpose was to this effect: that the pin holes were caused by small particles of graphite in the iron ore, which were not thoroughly extracted in the converting of the ore into bars, and where these small particles remained after the sheets were regularly rolled, then when heat was applied and the tin coating melted off, the graphite not resisting the action of the heat, pin holes would be the result. In those early days I never heard of the pin-hole fault in connection with the roofing plates; it always appeared in bright plates where such plates were used in manufacturing of vessels subjected to fire and heat.

In a nutshell—the complaints as to the quality of roofing tin are not well founded; where roofs do not give satisfaction it is owing to the changed conditions and not the inferior quality of the plates, and if tinners would pay more attention to these changed conditions and use higher grades of plates, and see that the roofs have better care, the result would justify an increased demand for tin roofing, and the increased demand would come if tinners would talk their business up instead of talking it down, and pay more attention to these outside influences. In other words, if you wish steel sheets with either a tin or terne coating, you can buy them as good as ever manufactured, but if such a roof does not last, it is either because you have not bought a roofing plate with the proper coating, or because of some of the other conditions such as I have named, or because of surrounding conditions beyond the control of the tinner; in such cases the tinner should use either a charcoal-iron roofing plate, or use some other material, or give the roof extra care if he would have it last.

A SHEET METAL WORKER'S VIEW OF THE TIN-PLATE QUESTION.

In a paper presenting the sheet metal workers' point of view of the tin-roof question, Mr. J. V. Dailey, of Cleveland, Ohio, advocated the following suggestions:

(1) Restoration of confidence in the use of the tin roof.

(2) Improvement in the quality of tin plate.

(3) The securing of a square deal in the drafting of the building code of the cities, and the repeal of discriminating sections favoring gravel roofs.

(4) Advertising by all interested in increasing the use of the tin roof, in such a way as to reach the individual consumer.

(5) Special investigation of the black sheet or base used in the manufacture of the tin plate.

(6) The reduction or abolishment of the tariff and reduction of the cost of our raw material.

(7) The use of a copyrighted brand on materials we can approve of using for tin-roofing purposes.

THE SHEET METAL WORKERS' RELATION WITH THE FURNACE TRADE.

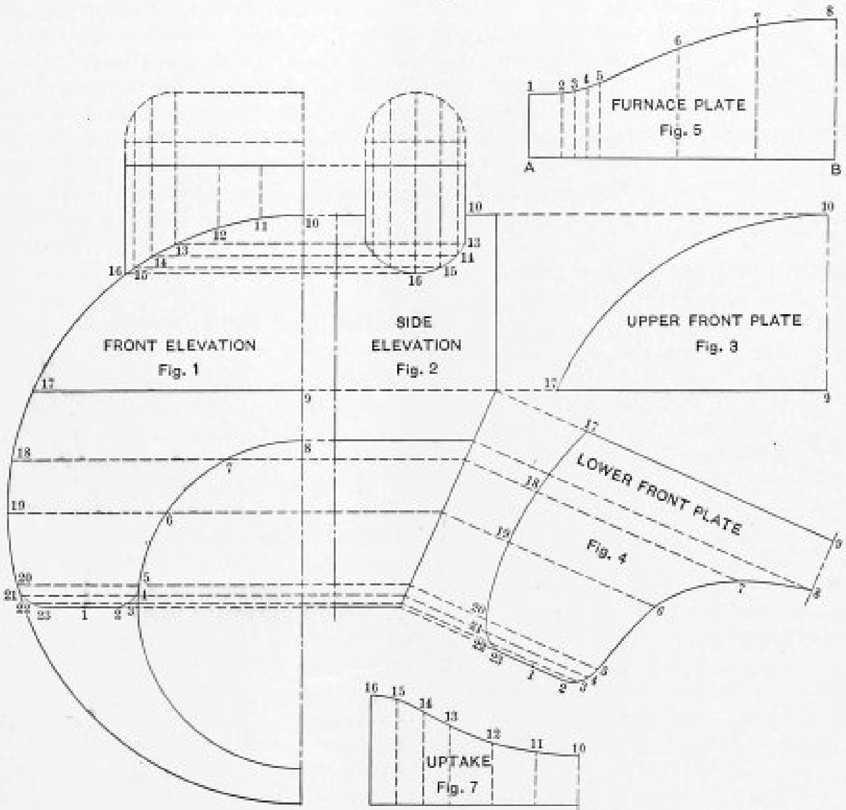
Mr. Charles S. Prizer, of the Abram Cox Stove Company, and president of the Federal Furnace League, presented a paper on "How Shall the Master Increase His Local Furnace Trade?" After dwelling upon the necessity for pure air and the installation of heating and ventilating plants such as furnish it, the writer gave his reasons why the correct and sanitary method of heating and ventilating a house is to put warm air into it in sufficient volume and to remove the colder and impure air from the rooms at the bottom thereof, which can best be accomplished by a warm-air furnace system of heating, provided the furnace has adequate capacity and is of right construction and correctly installed. He predicted that the contest for heating residences in the future will be between the direct steam or radiation system and the warm-air furnace methods. Heating by direct radiation is condemned by every hygienic and sanitary test, and in the face of the awakening of the public to the importance of fresh air for the preservation of health, it is difficult to believe that this method of providing artificial heat will long continue to be regarded with favor by any considerable number of people.

ELECTION OF OFFICERS.

The officers for the coming year are: President, Edwin L. Seabrook, Philadelphia, Pa.; secretary, Otto Goebel, Syracuse, N. Y.; treasurer, W. A. Fingles, Baltimore, Md. Louisville, Ky., was chosen as the place for the next convention.

plates at an angle, giving an irregular outline, it is necessary to choose a number of points on the outline of the plate, as shown in the front elevation, and project these over to the sloping line, which represents the plate in the side elevation. These parallel lines should then be projected to the pattern at right angles to the sloping line in Fig. 2; then, having located the center line 8-9, the distance 9-17 as measured from the front elevation can be laid out, and, in a similar manner, the other points 7, 6, 5 and so on up to 18 can be located.

Considering that the furnace plate, shown in Fig. 5, extends from the center line of the boiler at 8 around the furnace and across the bottom of the uptake to the point 1, it will be seen that the length of the plate must be made equal to the length of the curved line 1-4-6-8, Fig. 1. This is laid out on the straight line *A-B*, Fig. 5, and parallel lines are drawn at right angles to *A-B* at points 1, 2, 3, 4, 5, etc. The length of these parallel lines is then measured from the side elevation, Fig. 2, and laid off in the pattern; a curved line through these points locates the outer edge of the furnace plate.



Layout of an Uptake for a Scotch Boiler.

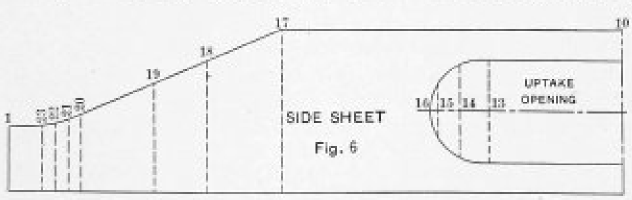
The uptake for a Scotch boiler includes a covering for the portion of the front head occupied by the tubes, and a smoke-box leading to the stack. Fig. 1 shows a half view of the front elevation for a single-furnace Scotch boiler. Fig. 2 shows the side elevation of the uptake; while in Figs. 3, 4, 5, 6 and 7 the half patterns for the uptake are shown.

The uptake is divided into an upper and lower front plate, a side plate, a bottom plate, which fits around the furnace and the uptake proper. The two front plates are plain surfaces and can easily be laid out from the drawing.

To lay out the upper front plate, shown in Fig. 3, it is only necessary to strike the arc 17-10, corresponding to the arc 17-16-10 in the front elevation, and lay off the cord 17-9, so that the height of the plate 10-9 is equal to 10-9 in the front elevation.

Since the lower front plate intersects the side and furnace

The side sheet extends from point 1, Fig. 1, around the outside edge of the boiler to a similar point on the opposite side. Therefore, the length of the lower edge of the pattern for the side sheet, shown in Fig. 6, should be made equal to the length of the line 1-22-18-16-12-10. Parallel lines should be laid out perpendicular to this line at the various points located in the front elevation, the length of these lines being determined upon the side elevation in the same manner as the length of the lines in the furnace plate was determined. The uptake opening in this sheet is made to accommodate an oblong smoke-box with circular ends. The development of



the line of intersection between the side sheet and the smoke-box or uptake is clearly indicated in Figs. 1 and 2.

From the projection of the uptake the half pattern for the sheet to form the lower end of the smoke-box can readily be obtained. It will be noted that, while the points 13-14-15 and 16 are equally spaced, the points 10-11 and 12 are not equally spaced, although they might very well be if so desired.

This problem is a very simple one in projection, and as the various lines are numbered similarly throughout the work, the location of the various points can readily be followed through. No allowance is made on the half patterns for laps, the lines indicating merely the outline of the sheets.

The British Locomotive Boiler.*

It is in the design of the boiler that the greatest variation in British locomotive practice is seen. It is now universally recognized that the power and capabilities of an engine depend entirely on the boiler. This is seen in the great advance in boiler power that has taken place recently, the cylinder dimensions remaining the same. Theoretically, the formula $3.3\ d^2$ will give in square feet the requisite heating surface for a cylinder diameter d. Thus, for an engine with 19-inch cylinders, 1,191.3 square feet would be enough. In Mr. Whale's "Precursor" class, now the standard express locomotive of the London & North-Western, 1,989 square feet is supplied for this diameter of cylinder, while on a recent engine built for the North British no less than 2,500 square feet is allowed to supply steam to cylinders 18½ inches diameter. The boiler for the "Precursor" class is 5 feet 2 inches diameter over the largest ring. There are three rings, lap riveted. This diameter of boiler enables the copper box to be much wider at the top than at the bottom. In ordinary boilers of this size this fact necessitates the fire-box covering plate being in three parts, so that the copper box can be inserted from the top. In this particular boiler, however, the steel covering plate is in one, the copper box and foundation ring being inserted from the back before the back plate is riveted in position. To enable this to be done the back plate is flanged externally, the rivet heads being thus on the outside and easily accessible for hydraulic riveting. There is no fire-hole ring, the copper being flanged outward to suit a similar flange in the steel plate. All rivet and stay holes are drilled. The water spaces are 3 inches wide on the foundation ring. The copper box is stayed with copper stays, 1 inch and 1⅛ inches diameter. The roof is stayed from roofing bars slung from the covering plate. The top of the back plate is stayed by gussets. There are no longitudinal stays between tube plates. The tubes are of copper, 1⅞ inches diameter. All steel plates are ⅝ inch thick, except the ⅞-inch smoke-box tube plate; all copper plate 9/16 inch except the tube plate, which is 1 inch. Steam is taken from a dome, where the regulator is situated.

The fire-box is generally the most troublesome part of the locomotive boiler. Roofing bars are heavy, and prevent the top of the box from being cleaned properly. Hence the introduction of the direct-roofing stay. With the ordinary curved covering plate direct staying is difficult, although D. Drummond has had great success with his method. The best method of direct staying is found in the Belpaire fire-box, in which the covering plate is flat topped. The Great Western standard boiler is the best example of the Belpaire type. The barrel is tapered, all the taper being above the center line. The Belpaire box is of the flush-topped type, while the sides of the covering plate also taper outward from the back. This method of tapering gives a great increase in the water and steam spaces about the box.

Belpaire boxes have either raised or flush tops. That is to say, the covering plate is either a few inches above the top of the last barrel ring, or on the same line with it. The flush-topped type is more expensive, as the covering plate flange on the front or throat plate has to be made by hand. The reason for this is that after the barrel flange has been made the flanging machine cannot make the covering plate flange satisfactorily, as the dies have no grip on the top of the throat plate. These conditions do not obtain on the raised top type, and so the throat plate can be flanged by machine.

Mr. Ivatt, of the Great Northern, does not bring the fire-box down between the frames, but carries it over on either side, thus securing a very wide box without restricting the water spaces. The tubes are 2¼ inches in diameter. Although there is a loss of heating surface by adopting tubes of this size, it no doubt results in less wear and reduction of weight in the tube.

To increase the most efficient portion of the boiler heating surface, Mr. Drummond has introduced inclined water tubes, which cross the fire-box from water space to water space. There are covers opposite the tube ends, studded to the covering plate, whereby inspection and renewal are simply secured.

The introduction of large-diametered boilers means a big increase in the height of the center of gravity of the whole engine, but given ordinary precautions this is preferable, as it entails less wear and tear on the permanent ways and wheels.

*Abstracted from a paper on the British locomotive read by A. W. S. Graeme before the Rugby Engineering Society.

Art and Science of Autogenous Welding.*

This process consists of welding or, more correctly speaking, melting together metals by means of the oxyacetylene flame, the temperature of which almost rivals that of the electric arc, being 6,300 degrees F. The facility with which it can be handled as compared with most other methods makes its commercial application comparatively simple. The possibilities attendant upon the use of a flame of such high temperature can be realized when it is remembered that the melting point of steel is about 2,570 degrees, and that of platinum, one of the most refractory metals, is only 3,227 degrees F. Its chief field of usefulness is in combining such metal parts as would ordinarily be riveted, in welding small parts together, in repairing broken or defective castings and for cutting metals of any nature or size that occasions demand.

Unquestionably the combustion of acetylene and oxygen was first suggested by the familiar oxy-hydrogen blow-pipe, but it was only after exhaustive experiments on the part of the noted French chemist Fouché that, in 1901, he was enabled to produce a successful burner using this highly explosive combination. He was led to use these two particular gases by his calculations, which showed the extremely high temperature that would be generated by their union. In 1902 he patented his first cutting and welding burners. In 1905 he took out additional patents, the principle of which has not up to the present time been appreciably altered or improved.

The most economical method of producing oxygen in commercial quantities is by means of distillation of liquid air, the cost having been reduced to something less than a cent per cubic foot. However, the familiar laboratory method of heating black oxide of manganese MnO and potassium chlorate K_2ClO_3, is largely used in this country, on account of the relatively low cost of the plant, although oxygen pro-

* From a paper read by E. S. Foljambe before the Society of Automobile Engineers at Detroit, Mich.

duced in this manner can hardly be sold for less than 2 cents per cubic foot at the present time.

The principal difficulty in designing a burner is to prevent the flashing back of the flame at the nozzle, which might cause an explosion. Even several wire screens have been proved ineffectual preventives, as the intense heat of the flame instantly raises the fine wires of the screen to a red heat. The method employed by Fouché consisted either in using a small bore tube of great length coiled into the cylindrical part of the burner, or of packing this space with mineral wool or asbestos, through which the gas could freely pass, but which successfully prevented the firing back of the mixture. As the tube is not of capillary size, it causes less resistance to the flow of the gas than the asbestos, and is therefore preferable. In a welding burner oxygen under about 10 pounds pressure per square inch is admitted through the small tube, and after passing out of a fine tipped nozzle, mixes in the injector-like chamber, and carries along with it the acetylene which has passed through the coil in the cylinder. The mingled gases burn, but beyond the tip, due to the pressure, so the tip itself is not subjected to a high temperature, and can be made of brass or even copper. In the welding flame the acetylene is only under a pressure of three-quarters to 2 pounds per square inch, and the oxygen 10 pounds. For cutting, the same combination flame is used, but in addition a third tube for pure high pressure oxygen is provided, and so located that the oxygen strikes the heated metal just to the rear of the combination flame. The oxygen for the cutting burner is under about 150 pounds per square inch, and the acetylene 10 pounds.

In operating the burner the acetylene is first ignited and the flame regulated by means of a valve at the end, so that it does not leave the tip. The oxygen is then turned on, the pressure being maintained constant by means of a reducing valve on the tank. The acetylene is then regulated until just sufficient to produce complete combustion, giving practically a non-luminous flame, in the middle of which, however, near the tip, a slightly luminous cone is seen, the point of which is the hottest part of the flame, and the burner is usually held in such a position that the tip of this cone touches the work. If an excess of oxygen is present the metal will very soon scintillate, showing that it is being burned. This, of course, has reference to the welding flame alone, as the cutting action is entirely due to an excess of oxygen in the flame.

When cutting, the combination flame is first turned on and used to bring the edge of the piece of metal to be cut to a bright red heat. Then the pure oxygen stream is turned on and the highly heated metal instantly combines with the oxygen, forming Fe_3O_4 in the case of iron, and a path is almost instantly melted out as the flame is moved across the piece. The amount of metal burned away depends upon the width of the zone heated by the fore flame and the volume and pressure of the oxygen. The complete localizing of the heat is a peculiar and surprising feature, for although the metal for about an eighth or three-sixteenths of an inch is actually running out of the cut like water, the adjacent metal is not heated to a dull red for more than half an inch on each side of the cut. For cutting thin metals, oxygen under such high pressure is not as essential as when the work is thicker, and it has been found that after the melting process, caused by the pure oxygen stream, has started, it is almost unnecessary to have the combination flame carried ahead of the stream of oxygen, as the heat is so intense that the action after once started can be continued. This has been shown by using simply the flame from a welding burner to heat the edge of the piece to the melting point and then suddenly turning off the acetylene, allowing the oxygen jet alone to impinge upon the heated metal.

In uniting the edges of a sheet rolled to form a cylinder, or wherever the pieces do not lap, the edges are beveled so that when brought together a V-shaped groove is formed, the width at the top of the groove being about the same as the thickness of the metal. This rule applies to metals up to half an inch in thickness. The flame is directed into this groove, first melting the thin bottom edges; at the same time a piece of wire of the same material as that of the parts to be joined is held in the edge of the flame, and this kept at a bright red heat until the metal of the parts begins to flow, when the wire is immediately plunged into the flame, and being instantly melted, drops into the groove, uniting with the metal at the bottom. This process is continued, thus building up the metal until slightly more than sufficient is placed in the groove to fill it, so the piece can afterwards be dressed to make the surface of the joint flush and invisible. Even dissimilar metals can be perfectly united, and such combinations as copper, brass, cast or wrought iron or steel, or brass to copper, are possible. Aluminum can also be worked successfully.

The different parts so united form one homogeneous piece, but with this distinction, that, while the metal of the original sheets has a grain, due to rolling, the built-up material of the joint has a structure similar to puddled metal. This is probably one reason why test specimens do not show a tensile strength equal to that of the original. However, as shown by the following report of the South Chester Tube Company on wrought-iron pipe material welded by the American-Ferrofix Brazing Company, the relative strength is very high, being

REPORT OF SOUTH CHESTER TUBE COMPANY.

	Ultimate Strength Pounds Sq. In.	Elongation Percent.	Elastic Limit
No. 1. Original bar...	49,580	11	.....
No. 2. Welded bar....	43,040	5	38,700
No. 3. Welded bar....	46,600	8.5	35,800

about 95 percent of the original piece, which is much higher than can be obtained by riveting. It is even possible to increase this to 100 percent by simply heaping up the metal at the joint until the cross-sectional area is somewhat larger than that of the original, but the elongation is noticeably decreased.

Although the cutting-off flame is of especial interest, its applications to construction work are much more limited than are those of the welding flame. In Paris, the flame has been used successfully on work as large as 6 inches in thickness, but so far as I am aware no cutting has been done in this country on work over 2½ to 3 inches thick. However, the burners are daily being perfected, and it is probably but a question of a short time when plates of considerable thickness can be successfully cut.

The cost of oxy-acetylene autogenous welding depends, of course, upon the size of the work, the price of the gas, and in no small degree upon the skill of the operator, so that very little can be definitely stated in regard to it. It is claimed that the expense of uniting sheet metal can be compared with riveting as follows: Up to ¼ inch in thickness it is cheaper than riveting; ½ inch about the same, while above ⅝ inch it is more expensive, the cost increasing approximately as the cube of the thickness.

The time required for cutting different thicknesses of metal from experiments made by the Baltimore & Ohio Railroad Company is as follows:

A section 13½ inches was cut from a ½-inch flat in 1 minute 10 seconds.

A section 12 inches was cut from a ⅝-inch flat in 1 minute 25 seconds.

A section 12 inches was cut from a ⅜-inch plate in 2¾ minutes.

A section 33 inches was cut from a 15 by 50-pound beam in 3 minutes.

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Wide versus Narrow Fire-Boxes.

Opportunities for variation in the design of locomotive fire-boxes are not very great. For practical reasons the shape of the fire-box and its size relative to the size of the rest of the boiler are limited with considerable exactness. It is obvious that the maximum width and height of the box are well defined, and its length must not be greater than can be fired by hand. Mechanical stokers may in time permit the use of exceptionally long fire-boxes, but at the present time their development is not sufficiently advanced to warrant such practice. Long before locomotives had reached their present enormous size and power, it was found that the old-style narrow fire-box would not give sufficient grate area for what was supposed to be economical combustion of the fuel. The idea was formerly held that higher rates of evaporative efficiency were obtained with slower rates of combustion, and with larger ratios of heating surface to grate area. It was not considered economical to burn coal at a higher rate of combustion than 100 pounds per square foot of grate area per hour. That this idea can no longer prevail is shown by the results of recent tests with narrow fire-boxes, in which economical results were obtained by burning 200 pounds of coal per square foot of grate area per hour, the reason for this being that it is possible to carry a deep fire in the deep, narrow fire-box, so that there is little chance for an excess of air to get through the bed of fuel and decrease the efficiency of combustion. Furthermore, it has been shown on good authority that boiler efficiency is independent of the grate area when the volume of the fire-box is constant. According to this the same results may be expected by burning 72 pounds of coal per square foot of grate area per hour on a grate containing 55.5 square feet of surface, as by burning 134 pounds of coal per square foot of grate area per hour on 29.76 square feet of grate area.

In order to carry out the idea that the efficient operation of a locomotive could be obtained only by not exceeding a certain rate of combustion, it was natural that wide fire-boxes should be used in order to give increased grate area. For practical reasons these wide fire-boxes have always been shallow, since they are usually placed above the engine frames. Great things were confidently expected of the wide fire-box, but, although it has been very generally used, it has not seemed to make any marked advance over the old-style narrow fire-box. Of course it is possible with it to maintain lower rates of combustion, but it is also necessary to maintain a much thinner fire, and, with such a large grate area, it is a difficult task to prevent holes from forming in the fire and allowing an excess of air to enter the furnace. At low rates of combustion excess of air is the principal cause for loss of efficiency, while at high rates of combustion the greatest loss is due to coal escaping unburned in the form of sparks and cinders. With narrow fire-boxes, working at their maximum capacity, the loss due to sparks and cinders frequently amounts to over 20 percent of the heat value of the coal. The fuel which passes off in this form usually has from 75 to 90 percent of the heat value of dry coal. Loss of efficiency, due to excess air in the furnace, which occurs in a wide fire-box with its thin fire and slower rate of combustion, is of great importance, as it not only carries away sensible heat, but also reduces the furnace temperature, thereby reducing the efficiency of the boiler. A series of tests once made to determine the excess of air at different depths of fire with uniform conditions with respect to draft, kind of coal used, etc., show a saving of 6.5 percent with a fire 12 inches thick over one of 4 inches thick. Whether this ratio of economy may be expected at all different intensities of draft is uncertain, and it varies with different kinds of coal.

In general it may be said that a very slight economy can be obtained with wide fire-boxes over narrow fire-boxes under the same conditions. While this is of the utmost importance, where the coal bill forms about 50 percent of the cost of maintenance of a locomotive, yet it is necessary to look to the question of repairs to see whether the advantage is an absolute gain. Here the narrow fire-box seems to have the best of the argument in almost every case. Wide, shallow fire-boxes invariably cause excessive flue leakage and repeated failure of side sheets and stays. In fact, reports seem to show that the number of leaky tubes and stay-bolts in wide fire-boxes, as compared with those in narrow fire-boxes, is about as 1 is to 10, while renewals of door sheets, crown sheets and side sheets are about three or four times as frequent in the case of wide fire-boxes as with narrow ones. Hence the relative value of the broad and narrow fire-box is a very uncertain question. There are still possibilities, however, that some innovations in fire-box design may yet be made. A wide fire-box of the same depth as the ordinary narrow box is not an impossibility, and theoretically such a design looks attractive. Also the possibilities of the combustion chamber and internal fire walls are by no means exhausted.

TECHNICAL PUBLICATIONS.

Consular Requirements for Exporters and Shippers. By James Shaw Nowery. Size, 5 by 7½ inches. Pages, 84. Glasgow, 1908: James Munro & Co. Price, 2/6 net; 75 cents.

This little book includes copies of all forms of consular invoices, with some useful hints as to drawing out bills of lading and other documents necessary in the shipping trade. As every shipper knows, or should know, attention to details is very essential, especially with regard to consular requirements imposed by various foreign countries, which often involves the perusal of lengthy documents. The author of this little book admirably sets out the gist of these in a concise and methodical form, which makes it an almost indispensable work to anyone engaged in export trade.

Manual for Engineers. By Charles E. Ferris, B. S. Size, 2¾ by 5½ inches. Pages, 248. Published by the University Press, University of Tennessee, Knoxville, Tenn. Price, 50 cents.

This is the eleventh edition of a small handbook containing useful information and tables for engineers. The book is by no means a complete handbook, but whatever information is given is in convenient form for ready use. A four-place table of logarithms is given with which it is claimed nearly as accurate work can be done as with the ordinary five-place table. The book contains such tables as squares, cubes and reciprocals, areas and circumferences of cricles, natural sines, tangents and secants, tables of the properties of saturated steam, earthwork tables and various data regarding the strength of materials.

The Slide Rule—A Practical Manual. By Charles N. Pickworth. Pages, 113 + xvi. Figures 30. Size, 5 by 7 inches. New York, 1908: D. Van Nostrand Company. Price, $1.00 net. London: Whittaker & Co., and Manchester, Emmott & Co., Ltd. Price, 2/6.

This is the eleventh edition of a work dealing with the use of a calculating rule, and takes up in considerable detail the methods of procedure in making computations by this means. Nearly all of the volume is devoted to the usual type of slide rule, being that in the form of a ruler 10 inches long. Special types of rules, however, are given at the end of the volume: the Fuller spiral rule, the Thacher cage-type calculating instrument and a number of circular calculators of the size and form of a watch being here described. Numerous examples are given, with explanations in detail of the method of obtaining results.

British Engineering Standards Coded Lists. Vol. V. Size, 8½ by 11 inches. Pages, 411 + xxxix. Structural Steel for Shipbuilding and Marine Boilers. Steel Castings and Forgings for Marine Purposes. Marine Code compiled by James Adamson. London, 1908: Robert Atkinson. Price, 25s. net.

The British Standard Marine Code is designed for the use of shipowners, ships' officers, shipbuilders, marine engineers and all those handling marine material, whether afloat or ashore. The latest details in all the various matters coming within the scope of modern marine engineering are carefully and systematically dealt with; and as the compiler has had a long experience of requirements for ships under various circumstances, he has incorporated the results in a most convenient form for ready reference by every one whose duty or interest lies in the direction of shipping and ships, sea or river navigation.

The code is divided into sections, and the index itself is a useful compilation for general service by all those whose business is connected with water-borne traffic. The ship is dealt with in a great many varied circumstances of location, of suitability for cargoes, of damage and repairs, under conditions derived from experience, including dry-docking and surveying necessities or requirements. The machinery in all details of latest equipment of turbine, watertube boilers, forced draft, hydraulic, electrical, refrigerating, steering gear and deck machinery are treated fully for repairs in all cases where found necessary.

In addition to the propelling machinery, all other machines, such as evaporators, feed-water filters and feed-water heaters, are also treated fully, with phrases for reporting condition of machinery, details, repairs, or renewals required; also ordering phrases for material connected with boilers and machinery, whether propelling or auxiliary. The propeller is dealt with under every circumstance; and with the assistance of a convenient sketch, a shaft can be ordered by telegram in full detail, or dimensions confirmed. The turbine has a section to itself, and is given in minute particulars for all classes of repairs. The diagram for the location of turbine units, together with the phrases, will be found most useful.

Besides the marine code, this volume contains coded list of the British standard sections, and specifications for structural steel for shipbuilding, for marine boilers, ingot steel forging and steel castings for marine purposes. The great value of a good index in saving time and temper is well known; this has evidently been kept in view by the compiler of the code.

Board of Trade Arithmetic for First-Class Engineers. By Peter Youngsen. Pages, 108. Figures, 19. Size, 4¾ by 7 inches. Glasgow, 1908: James Munro & Co. Price, 3/– net and $1.00.

The work consists of a series of sixteen papers of questions asked at Board of Trade examinations for engineering licenses. Each paper consists of a considerable number of questions, and is followed in the second portion of the work by answers to these questions. The questions cover computations and explanations of various boiler calculations, size of coal bunkers, coal consumption, propeller data, engine horsepower and elementary navigation, besides a large number of questions of a general arithmetical nature, and dealing largely with marine engineering subjects.

In the preface it is pointed out that the carrying out of results to a large number of decimal places is not usually called for, and stress is laid upon the importance of carefulness in the steps leading up to the result rather than too much refinement in the result itself.

PERSONAL.

Charles Beard has resumed his former position as foreman boiler maker of the Guayaquil-Quito Railway Company, at Duran, Ecuador, South America.

In accordance with the new boiler inspection laws the city of Scranton (Pa.) recently held competitive examinations for the position of city boiler inspector. From the five successful applicants who passed examinations Mr. Charles R. Flint was selected to fill the position.

The partnership heretofore existing between Messrs. Allison & Dixon, boiler makers in Punxsutawney, Pa., has been dissolved by mutual consent, Mr. Dixon retiring from the concern. The business will hereafter be carried on under the direction of Mr. William Allison.

The Champion Rivet Company has appointed Mr. Alexander S. Mitchell its representative in New York City and vicinity, with offices at 45 Broadway. Mr. Mitchell has been identified with the iron and steel business in New York for the past thirty years, and will make it a point to secure prompt deliveries of Victor boiler, ship and structural rivets.

H. V. Westhouse is foreman boiler maker and C. C. Duffy is assistant foreman boiler maker at the Atchison, Topeka & Santa Fe Railroad shops, San Bernardino, Cal.

As a result of competitive examinations held in June, J. C. McCabe has been appointed chief boiler inspector of the city of Detroit, and A. F. Martin assistant inspector.

Frank B. Kleinhans, author of *Boiler Construction* and numerous scientific articles on boiler making, was killed Sept. 1, while driving near his home in Beechview, Pa.

C. J. Donohue, formerly secretary to the vice-president of the New York Central Railroad, has recently been appointed secretary to the president of the American Locomotive Works Company, with offices at 30 Church street, New York.

George Wagstaff, formerly supervisor of boilers of the New York Central lines, has become associated with the American Locomotive Equipment Company, of St. Louis, Mo., as their Eastern representative, with offices at 62 Liberty street, New York City. Mr. Wagstaff has a wide acquaintance among railroad men in the East, gained not only from his former position, but also from his connection with the International Master Boiler Makers' Association, of which he was the first president.

COMMUNICATIONS.

Patch for High-Pressure Boiler.

Editor The Boiler Maker:

The article of Mr. Brock's in your August issue was read with much interest and I thank him very much for his information concerning the Scotch boiler patch. Since I have had very little experience with marine work I did not give it a thought at the time of writing the article referred to, but was giving my whole attention to stationary boilers, and especially to locomotives. The tap referred to was made in the tool room at the shops, and made a good full thread and a tight fit for a ¾-inch patch bolt, even though the tap was run in clear up to the end of the threads in a 21/32-inch hole. Since copper and iron have not the same percentage of expansion and contraction I would like to see more written on this subject, as I have always been taught to get my work up iron to iron. I saw a patch put on once with a copper liner under it, and it gave a good deal of trouble. It was calked so much that it had to be taken off and renewed in a very short time.

G. W. Smith.

Proving Lamination in a Boiler Plate.

Editor The Boiler Maker:

I had been a marine engineer for many years, and when our company gave the contract for two new ships I was sent to the rolling mill as inspector of material for the hulls and boilers. When I first started out on my new duties I confess I did not have the confidence in myself which I acquired after several months' experience with several pretty sharp mill superintendents; but after a while I could tell the difference between basic and acid steel, and could talk understandingly of snakes, laminations, sand or scale marks, scabs, pits and defects generally, and was considered an expert with a slide rule or Thatcher calculating machine.

One day when I condemned a large steel furnace plate for being laminated I simply brought the whole mill down on me, so to speak. Even the roller, who had occasionally condescended to accept one of my cigars, looked at me with pity. "A laminated steel plate! Nonsense! That little crack which you see on the edge of that plate was caused by being rubbed up by the mill housing and rolled under on the back pass of the rolls, and will shear out," said the superintendent. I told him my specifications were very plain, and I would be obliged to reject the plate, at which he became angry and went to headquarters, making remarks in an undertone, which, to say the least, were not very complimentary, and it was not long before I was surrounded by all the steel experts of the establishment. After I had listened to all sorts of arguments, until life had commenced to be a burden, I asked the superintendent if he would allow me to prove to him that I was right. He was magnanimous enough to give me permission to do so, provided I would be responsible for the value of the plate if I did not substantiate my side of the point in question. I at once had some holes punched along the edge of the plate where the cracks appeared, and drove some rivets in the holes; I then had the plate taken to a forge and placed over a hot fire while a stream of cold water was allowed to play on the opposite side. These were the conditions in an exaggerated form to which the plate would be subjected if incorporated in a boiler. It was not long before a bulge commenced to develop on the side next to the fire, while the side on which the water was playing remained quite smooth. After the bulge was extended about an inch I looked around for some of my friends to ask them their opinion regarding the lamination of steel plates, but they had all disappeared.

One day the superintendent asked me how I happened to think of that method for proving them wrong, and I told him it was only a part of the experience of an engineer who constantly met all kinds of problems in boilers, and I had reasoned that if the ingot from which the plate had been rolled was not perfect, that it contained dirt or other foreign matter, or had shrinkage cracks, the plate would not be perfect, no matter how much it was rolled. I had judged that the plate in question was rolled from a slab made from the top of an ingot, although it is not customary in most mills to use the top for boiler plates, the center being considered the best. He agreed with me.

Boiler Plate.

Round-House Flue Work.

Editor The Boiler Maker:

I will endeavor to answer to the best of my ability the communication of Mr. J. R. Cushing in the August issue of The Boiler Maker. He claims to get more mileage from engines with tubes 20 feet long than from one with tubes 11 or 12 feet long. I will not doubt his word, but the case is just the opposite in this part of the country. Before the long-tube engine was put in service it was a very rare thing for a boiler maker to have to roll tubes in an engine in the round house. Engines would stay in constant service for sixteen to twenty months before any tubes were taken out, and then they were taken out on account of the mud in the boiler and on the tubes, and not because they gave trouble by leaking. I did make the wager with the engineer on the five runs and won, but could not get the engine to hold up more than two trips after that. The factor of safety Mr. Cushing speaks of is more theory than anything else, according to my way of thinking. I have worked on tubes that have pulled half way through the flue sheet, the ends of the tubes having been rolled until they were as thin as paper, although the engine carried 200 pounds of steam. Anyone having any doubts about this can verify these statements by writing to Mr. John Cummins, R. F. foreman at Fulton round-house, Richmond, Va., C. & O. R. R., and from the same source information can be obtained regarding the ability of the boiler makers under his charge and their honesty in respect to their work.

Another point in regard to the factor of safety. Some time ago an engine was shopped for repairs and the following conditions were found. Between 80 and 100 stay-bolts were broken in different parts of the box, thirty-two in one batch;

the door sheet was cracked in the heel, or root of the flange, for a distance of 3½ inches. The side sheets were pitted and eaten so badly in all four corners of the fire-box that holes were punched through when the sheets were being cleaned off with a chisel. The cracks had been sewed up in the sides from the second row of stay-bolts up to, and in some cases extending beyond, the fourth row of bolts; five of the six belly braces were broken completely in two. After the flues and mud-ring were taken out the shell was given a good examination, and was found to be in very bad condition, especially along the girth seams. The sheets were eaten away very badly; in some places they were almost through. The front flue sheet was examined, and seven bridges were found cracked in the extreme bottom of the sheet and the back tube sheet was bulged in the center. I ask Mr. Cushing if he or anyone else can explain where the factor of safety was when this engine was making her last trip before coming to the shop.

In reference to the prosser tool, I still claim it a worthless tool on tubes that have been tightened in both sheets, as I have always gotten better results when the roller tool was used, followed up by the beading tool. I think the beads should be calked up good and solid every time the rolling tool is used on old flues. Leaky flues seem to be a universal trouble, and one to remain with us for some time to come. Every known remedy has been applied with the same results. The boiler makers in convention have done very little to help the cause. The foreman boiler maker cannot give any information or suggest anything that will keep them from leaking. The latest improved tools seem to help but very little, if any. The boiler designers have not helped the cause any, and still the poor boiler maker gets all the blame for the trouble. G. W. SMITH.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Give a rule for figuring the pressure to be placed on a spring-loaded safety valve. J. S.

A.—The load to be placed on a spring-loaded safety valve would be equal in pounds to the area in square inches of the inside of the valve in communication with the steam inside the boiler, multiplied by the pressure in pounds per square inch at which it is desired to blow off. If the area of the valve is 6 square inches, and it is desired to blow off at 200 pounds per square inch, the spring should be so adjusted as to create a thrust against the valve seat of 1 200 pounds.

Q.—Please differentiate between the Clyde boiler and the Scotch boiler. G. W. T.

A.—The Scotch boiler is one having one or more internal flues or furnaces, with return tubes around and above these flues for the passage of the products of combustion to the up-take and funnel. The front end of the furnace is located at the front of the boiler. The rear end of the furnace opens into a combustion chamber, which connects the furnace with the tubes. The tubes, furnace and combustion chamber are entirely surrounded by water (except, of course, in the front end, where the furnace is arranged for firing and the tubes for discharging the products of combustion up the stack), this water being contained within the cylindrical shell of the boiler. This boiler is also known as the cylindrical marine boiler, and sometimes as the return tubular boiler.

The Clyde boiler is of the same general type, except that the combustion chamber is not surrounded by water. For this reason it is often called a "dry-back Scotch boiler." It is not used to any extent in marine service, and has in general only one furnace, where the Scotch boiler frequently has four.

The Scotch boiler is often made double-ended, each end being a duplicate of the other, and having usually either three or four furnaces in each end. In such case the combustion chambers for the two ends are sometimes merged into one common chamber, but more often two chambers are used, separated by a water space with a thickness of 4 or 5 inches.

Q. 1.—How many rivets would be required to rivet a dome, 36 inches inside diameter and 7/16 inch thick, to a boiler carrying 110 pounds steam pressure?

2. How many and what diameter of stay-bolts would be required to brace the fire-box of a vertical boiler carrying 100 pounds steam pressure? The shell of the boiler is ⅝ inch thick and 46 inches diameter; and the fire-box is 5/16 inch thick and 40 inches diameter.

3. How do you determine where to place the gage cocks and water glass on a vertical boiler R. E. H.

A. 1.—First find the area of the steam dome and multiply this by the steam pressure to get the total force tending to tear the dome from the boiler shell. Since the inside diameter of the dome is 36 inches, the area will be $.7854 \times 36^2 =$ 1,017.88 square inches. Multiplying this area by the steam pressure, 110 pounds, we find that the total pressure on the dome is 111,966.8 pounds. It is customary to use a ⅞-inch rivet with 7/16-inch plate, which would make the diameter of the rivet when driven 15/16 inch. The area of one rivet would, therefore, be $.7854 \times (15/16)^2 = .69$ square inches. Allowing a stress of 10,000 pounds per square inch on the rivet, which would be equivalent to using a factor of safety of 6, the strength of one rivet in tension would be 6,900 pounds. Therefore, dividing the total pressure on the dome, which was found to be 111,966.8 pounds, by the allowable pressure on one rivet, 6,900 pounds, we find that 16.2, or 17 rivets, would be required. The diameter through the line of rivets would, however, be about 40 inches, making the circumference 125.66 inches, and if only seventeen rivets were used, the pitch would be about 7½ inches. This, of course, would be too great to make a steam-tight joint with a single row of rivets, and as the rivets would not be subject to a purely tensile stress but partly to a shearing stress, it would be necessary to use a much smaller pitch. A double row of ⅞-inch rivets, spaced about 3 inches center to center, would make a joint with an efficiency of about 68 percent, which would be suitable to use at this place, as a large factor of safety should be allowed.

2.—The number and size of stay-bolts to brace the fire-box of a vertical boiler should be figured as though the fire-box were a flat surface instead of a circular one, since the diameter of the fire-box, compared with the thickness of the plate, is so large that the fire-box itself, considered as a tube, would not be capable of resisting very much pressure. First find the pitch of the stay-bolts, which depends entirely upon the thickness of the plate, and the steam pressure carried.

$$p^2 = \frac{115 \times (t)^2}{P}$$ where p = pitch in inches; t = thickness of fire-box sheet in sixteenths of an inch; and P = working steam pressure in pounds per square inch. Substituting the values given in your question, we have

$$p^2 = \frac{115 \times (5)^2}{100}$$

$$p^2 = 28.75.$$

$$p = 5.36 \text{ inches pitch.}$$

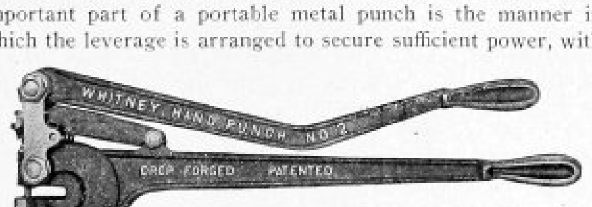
If the bolts are to be spaced 5.36 inches apart, each bolt must support an area 5.36 inches square, and the total pressure on this would be $(5.36)^2 \times 100$, or 2,875 pounds. Allowing a stress of 6,000 pounds per square inch in the stay-bolt, we shall have to make the area of the bolt times 6,000 pounds equal to 2,875. Therefore, $.7854 \times 6{,}000\ d^2 = 2{,}875$; $d^2 = .6101$; $d = .78$ inch diameter. This is the diameter of the bolt at the bottom of the thread. If there are twelve threads to the inch the diameter of the outside of the bolt would be 15/16 inch. The number of bolts required would be found by dividing the total area of the fire-box sheet by the area supported by one bolt. We have seen that such bolt is to support an area of 28.75 square inches; and since the fire-box is 40 inches in diameter and 42 inches high, its area will be $3.1416 \times 40 \times 42 = 5,277.72$ square inches. Dividing 5,277.72 by 28.75 we find that 184 bolts would be required.

3.—If the boiler is of the submerged tube type; that is, has an upper tube sheet below the level of the water, the gage glass should be so located that when the water is just in sight the level of the water is from 2 to 5 inches above the tube sheet. The height of the glass should be about 10 or 11 inches, and the working level of the water should be at about the middle of the glass. If the boiler is not of the submerged tube type, the glass should be located so that when the water in the boiler is at its normal level it will show at the middle of the glass. This, of course, must be determined from the design of the boiler in which the water level is determined, so as to give the proper relation between steam and water space in the boiler. At least three gage cocks should be fitted in addition to the water gage. The top one is frequently placed about 1 inch above the top of the glass in the water gage, and the bottom one an inch below the bottom of the glass, with the third one half-way between the other two. In horizontal boilers the bottom cock is frequently placed at the level of the top of the combustion chamber; but, of course, this would not be done in a vertical boiler. The gage cocks should not be placed vertically one over the other, as in that case the upper ones will drip onto the lower one. They should be offset slightly one from the other.

ENGINEERING SPECIALTIES.

The Whitney Portable Hand Metal Punch.

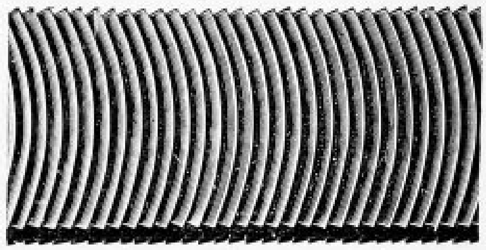
In designing the Whitney portable hand metal punch, the W. A. Whitney Manufacturing Company, Rockford, Ill., took particular care to combine strength, lightness and simplicity with durability, so that the tool would not only be an efficient punch, but also a convenient portable machine. It weighs only 11 pounds and is 23 inches long over all. The power lever is 22 inches long and punches from ⅛ to ½ inch diameter can be used. The capacity of the No. 2 size machine is a ⅜-inch hole through ¼-inch iron or its equivalent. Of course, the important part of a portable metal punch is the manner in which the leverage is arranged to secure sufficient power, with



a reasonable effort on the part of the operator. The upper operating lever in this machine is supplied with two sets of teeth, which engage similar teeth in the small intermediate member holding the punch. Upon each of these two pieces is an extra hardened roller surface bearing, designed to carry the crushing force. This is an arrangement which produces a very powerful leverage, so that the punch can be operated at a large capacity with little effort. The machine is of drop-forged steel throughout, and the punches can be quickly changed by throwing over the upper lever and raising the small intermediate member. There are no nuts or bolts to be removed. The die is divided and can likewise be easily changed or adjusted.

The Vixen Patent Milling File.

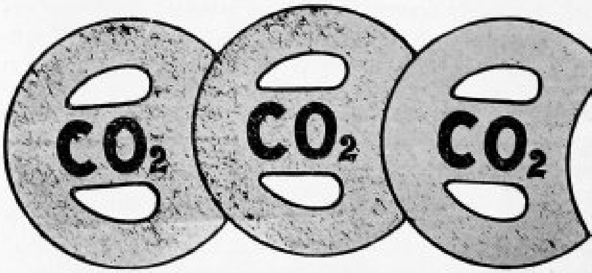
The "Vixen" patent milling file has semi-circular teeth on both sides, cut especially deep, which give to the filings the nature and shape of turnings or shavings produced by a modern lathe or milling machine. A special back, or holder, is used in conjunction with the file, which enables the mechanic to get a much greater purchase, and so to utilize to the fullest extent the superior cutting qualities of the file. The shape of the teeth not only makes the file act essentially as a



milling cutter, but it also tends to keep the file clean, an object which is hard to accomplish with an ordinary file, especially when working on soft metals. The shape of the teeth also prevents the file from slipping or chasing, and leaves a smooth, even surface. It is claimed that the file cuts equally well soft and tool steel, cast and wrought iron, bronze and all other hard metals, as well as brass, lead, aluminum and other soft metals. The file can be resharpened at least four times, each operation costing about half that of recutting an ordinary file. Moreover, it is claimed that, after resharpening, the file is quite as good as new, and, therefore, may be expected to last several times as long as an ordinary file. This file is manufactured by the National File & Tool Company, the Bourse, Philadelphia, Pa., and 8 White street, Moorfield, London, E. C., England.

The C-O-Two Furnace.

Smoke prevention, from the point of view of economy, as well as for other considerations, is eminently desirable. To prevent smoke, it is necessary to secure complete combustion of the fuel. In order to do this, the gases must have a chance to thoroughly mingle with the correct amount of oxygen at a sufficiently high temperature before being brought into contact with the water-cooled metal surfaces of the boiler. The C-O-Two Furnace Company, of Syracuse, N. Y., have



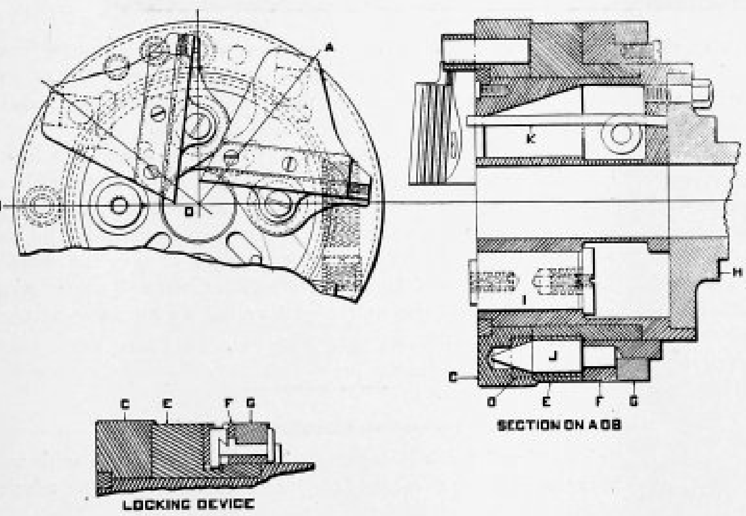
recently placed on the market a new form of highly refractory furnace tile, the use of which, it is claimed, will give the proper conditions for smokeless or complete combustion as outlined above. The tile is the result of this company's effort to perfect a fire arch or Dutch oven, in which is combined strength, durability, ready application to any rise and expansion, facility of erection, and, through its body, the introduction of air in normal quantities into the furnace in a greatly heated and expanded state, delivered at points most suitable for producing a thorough mixture of oxygen with the volatile gases, thereby obtaining perfect combustion. From the illustration it will be seen that the tiles have a solid transverse wall, which is capable of taking up any reasonably wide thrust. Furthermore, this center wall is but little subject to expansion and contraction, since the air currents flowing through the perforations tend to take up the excess of heat within the archbody without reducing the inverted surface below the incandescent state required for ignition. The arch is thereby prevented from melting down, and from distortion, due to sudden cooling.

Air is admitted into the channels formed by the consecutive tile members, preferably by way of a suitable distributing chamber, within the front wall, into which it is led by syphon action, which may be produced by a small steam jet or by a blower. In some cases it may be taken in by natural draft. The exit ports are produced by cutting the tile at convenient points. These ports can therefore be shaped and located to suit the conditions existing in any particular furnace or boiler. By varying the angle of deflection at which the air is allowed to escape, the proper relation can be obtained between the furnace vacuum and the initial pressure of the air, plus its increase in volume gained by the absorption of heat during transmission. If desired, the air may be guided so as to enter first the upper channel, passing back through the lower channel.

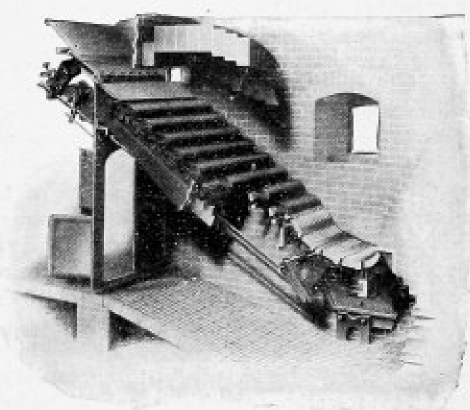
A New Type of Bolt-Cutter Die Head.

The die head of the Landis bolt cutter has been designed to meet the demands for a bolt cutter for high-speed work and accuracy, as well as admitting of flexible rake in the die, accommodating the die to the various kinds of material that come up in daily practice. The head is made entirely of steel, the heavier parts being made from cast steel, the spindles from high-grade machinery steel, and the smaller parts from tool steel. All the main bearing parts are hardened and ground. The die locks within the head and the yoke is not relied upon to hold the die closed while cutting or for carrying any of the cutting strain.

The line cut shows a section of the head on *A O B* passing through one of the spindles *I*, to which the chaser holder is securely clamped and which carries the greater part of the cutting strain. The same section shows one of the large cone pins *J*, which moves longitudinally with ring *F* and works in hardened bushings in ring *C* to rotate same, which opens and closes the die. Spring *K* engages the chaser holders and gives quick and positive opening to the die, and at all times takes up the back-lash that might possibly occur from slight wear. This spring is made with one coil, so as to give it a uniform tension in its different positions. To open the head, ring *C* moves back, raising the locking latches from behind their hardened seats, when the springs quickly open the die, and when the die is closed it is positively locked and there is no possible strain on the yoke. The tangent adjusting screw engages the head body proper and is located in ring *E*. Graduations on the rear of the head determine the setting positions for different diameters. Spindle *H* of the machine proper is fitted into the head in such a manner as to avoid any possibility of the head working loose from the spindle. The vertical pin in the locking device, with the angle head, drops in behind a hardened plate and is held there by a flat spring in ring *G*. In opening, the ring carrying the horizontal pin starts to move back, raising the vertical pin until it unhooks behind the hardened plate and the die quickly opens. There are two of these locking pins located on opposite sides of the head. Spindle *I* acts only as a support for carrying the cutting strain of the die. The die is opened and closed through the actuating of ring *C*. This ring is in turn operated by cone pins *J*, one being located on each side of the head. When this ring rotates, the sliding shoe in the chaser holder moves the chaser holder back or forth at its periphery, causing the die to open and close from a central point.



SECTIONS OF LANDIS BOLT-CUTTER DIE HEAD.



RONEY STOKER.

Any rake can be given the dies in grinding that may be desired to suit the kind of material you may wish to cut. This rake can readily be ground to get a rolling chip at all times the same as would be procured from a lathe tool. This flexible rake makes it easy to acquire the highest possible cutting speeds that can be had from any die, as the cutting clearance in the die is correct and there is no possible drag in the die. These dies can be made to advantage from high-speed steel, as they never require annealing, hobbing or retempering.

These machines are built by the Landis Machine Company, Waynesboro, Pa., in single, double and triple heads, with either belt or motor attachments.

The New Model Roney Mechanical Stoker.

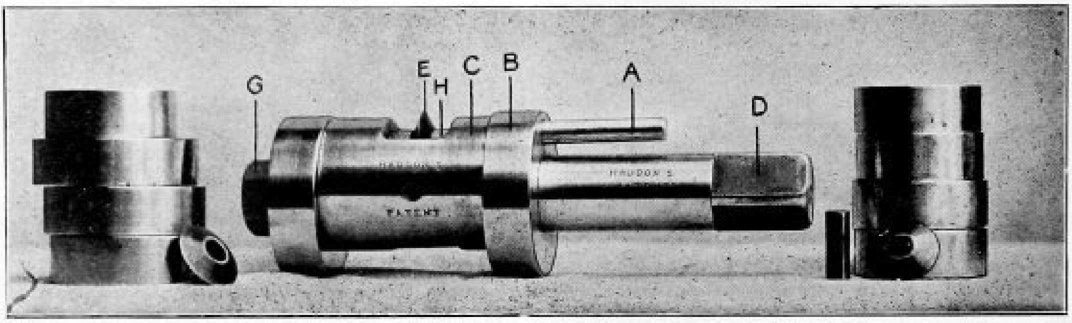
A new model of the well-known "Roney" mechanical stoker, manufactured by the Westinghouse Machine Company, East Pittsburg, Pa., has recently been placed on the market. As in the old model, the coal is fed into a hopper, extending across the boiler front, usually by gravity from an overhead bin. From this hopper the fuel is automatically supplied to the furnace by a reciprocating pusher operated from the rocker shaft by an eccentric. The fuel descends through the throat of the arc onto the upper grate bars, where it is subjected to an intense heat radiated from the incandescent firebrick arch spanning the upper portion of the furnace. It is claimed that this entirely cokes the fuel and draws off the volatile gases, leaving the coke, or fixed carbon, which is then gradually worked down the inclined surface by the rocking motion of the grate bars, imparted to them from the eccentric on the rocking shaft. The oscillation of the grate bars not only works the fuel slowly down the furnace, but also keeps it constantly agitated, thus preventing to a large extent the formation of clinker and bringing the fuel into immediate contact with the incoming air. After the solid combustibles have been totally consumed, the remaining ash is discharged onto a dumping grate at the bottom of the furnace.

From this brief description it is evident that the following essential condition for high rates of combustion and smokeless operation have been realized, namely. The fuel is fed to the furnace at a uniform rate depending upon the load; the fuel is coked in the presence of a preheated air supply, and the combustion is brought into intimate contact with the required quantity of air for complete combustion.

Among the most important features of the new Roney stoker is the sectional grate bar, or fire top; for the upper grates a new sifting type bar is used, provided with abutting horizontal ledges to prevent the fine fuel from sifting through the bars and at the same time permitting a free entrance of the air. For each square foot of the bar exposed to the fire there are 7.4 square feet of surface exposed to the air, so that the bar is amply cooled. From tests of these standard fire tops it is shown that there is an average annual depreciation of about 17 percent, indicating a probable life of about six years if the bars are redistributed from time to time. The new type of grate prevents the fire from sliding into the ash pit when the dumping grate is operated. The dumping grate itself is hinged about one-third forward, dumping both front and rear. The air supply, to effect the combustion of volatile hydro-carbons, which is one of the most essential requirements for smokeless combustion, is admitted through two wind-gates located at either side of the stoker. It first passes to the rear of the firebrick arch, extending across the front of the furnace, and is then directed by baffles to the crown of the arch, at which point it enters the front air spaces; from the latter it enters the furnace through the spaces between the stoker front and the first ring of arch brick. Passing the air over the furnace in this manner not only preheats the air but assists materially in cooling the arch. The firebrick arch is of such extent and so designed that it completely cokes a green fuel and directs the gases downward over the hottest part of the fire, therefore permitting the volatile gases to be completely consumed before coming in contact with any of the boiler-heating surfaces.

Haddon's Patent Internal Tube Cutter.

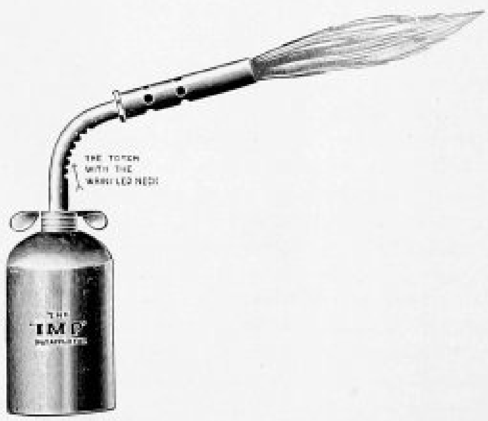
A new tube cutter, which can be operated with exceptional speed, has been devised and patented by Mr. I. J. Haddon, of 81 Railway street, Cardiff, Wales. The tool consists of a spindle *D*, with an eccentric so spaced that when the spindle is turned one-half a revolution it lifts a sliding block *H*, containing the cutter wheel *E* sufficiently to penetrate the tube. Then, if pin *A* is taken out and the spindle turned a complete revolution in the same direction, the tube will be perfectly severed. By taking off the nut *G*, withdrawing the spindle, turning around the sliding block *H* and replacing the spindle and nut, the tool can be used to cut in the opposite direction. This is an advantage of considerable importance for a tool which is to be used in marine work, because it can be used either right or left handed from either the front of the boiler or the combustion chamber. There are ten rollers or washers *B* with each tool, so that it may cut two different sizes of tubes of varying thickness, the size of roller being governed by the outside diameter of the tube and its thickness. As an example of the speed with which this tool can be used, a case is cited where a new 3½-inch tube, with a thickness of No. 8 B. W. G., was cut off in 22 seconds from the time the tool was first taken up to the time it was put down again, and it is claimed that with this tool a man should easily be able to cut 60 tubes an hour.



With this cutter no other tools are necessary, except a hammer and punch to remove the short ends left in the tube plate. The tubes may be cut off 6 inches from the tube plate if desired, although a distance of 2 inches is recommended by the inventor. The length of wrench required to turn the spindle is about 2 feet, and by taking the cutter out and substituting suitable washers, the tool may be used as an internal pipe wrench for running in stay-tubes.

A Powerful Gasoline Blow Torch.

The "Imp" torch is a patented device which, it is said, will do as much work as most of the larger torches, with the advantage of compactness, simplicity and cheapness. It is entirely automatic in operation, has no pump or valve, needs no tools, starts with a match and gives a perfectly clean, power-



ful Bunsen flame for over two hours on four ounces of gasoline. The corrugated neck increases the heating surface to such an extent that the flame of a match easily generates gas enough for starting, after which the mixing tube renders further attention unnecessary.

The "Imp" is designed for electricians, automobilists, the handy man and anyone who wants intense, clean heat, cheaply and quickly. It is made by the Frank Mossberg Company, Attleboro, Mass.

SELECTED BOILER PATENTS.

Compiled by
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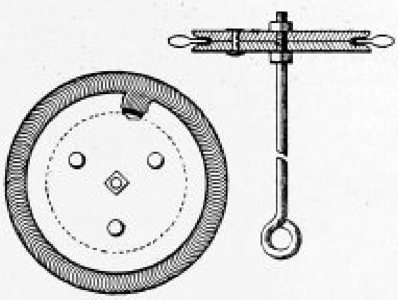
LOAN AND TRUST BUILDING,
Washington, D. C.

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

894,857. FLUE CLEANER. Lyman C. Rogers, of Mancelona, Mich.

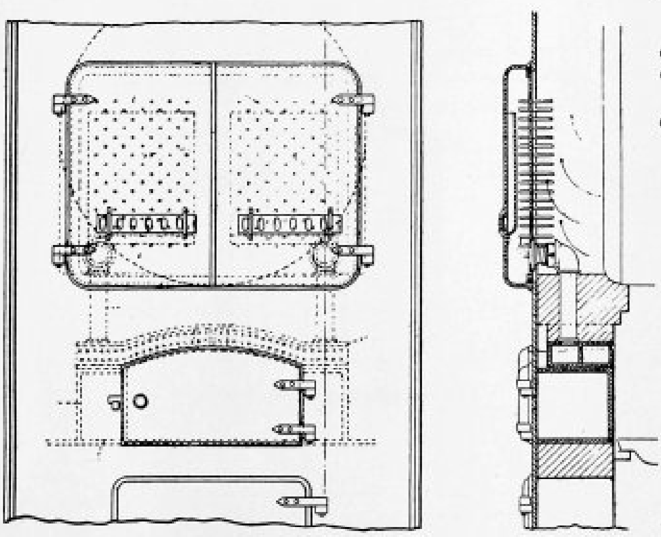
Claim.—A flue cleaner comprising a head composed of two members secured together and provided with a peripheral



groove and oppositely disposed clamping members, and a continuous series of wire coils secured in said groove by a holding wire passing through all of said coils. One claim.

894,856. BOILER FURNACE. John S. Roake, of New York, N. Y.

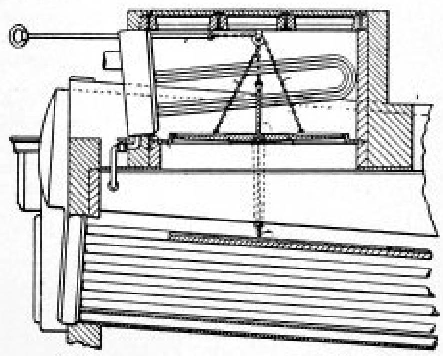
Claim.—In a furnace, a hollow front connection door, the interior of said door constructed to serve as an air heating chamber, said door having air inlet openings through the



front plate of said door, a damper controlling said openings, a discharge nipple on the rear plate of said door, a hollow arch having apertures leading to the furnace, a stationary pipe leading to the interior of said arch, and a yielding separable connection between said nipple and pipe. Four claims.

895,187. SUPERHEATER. Edward D. Meier, of New York, N. Y.

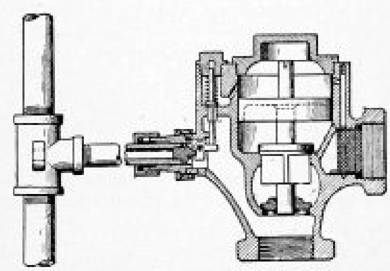
Claim.—In a steam boiler, a water receptacle having a horizontal passage for fire gases extending longitudinally beneath and along the sides thereof, in combination with a structure



forming a chamber over said receptacle having communication with said fire-gas passage on either side of said receptacle, a superheater contained within said chamber, and means for controlling said communication. Fifteen claims.

895,342. BOILER FEED VALVE. George W. Collin, of Mansfield, Ohio.

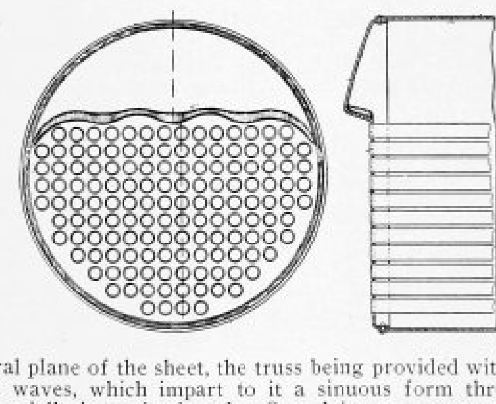
Claim.—A feed valve connected with a boiler, a bushing attached to the valve casing, an auxiliary valve, a lever fulcrumed to the casing and having an end for engaging the stem



of the auxiliary valve, a thermostat also connected with the boiler and being located at the normal water level thereof, and slidably engaging said bushing and having contact with the power end of said lever. Four claims.

896,045. BOILER TUBE SHEET. Garrett H. Rheutan, of Fitchburg, Mass., assignor of one-half to Robert B. Lincoln, of Waltham, Mass.

Claim.—A tube sheet for fire-tube boilers having a truss crossing the sheet transversely and presented edgewise to the



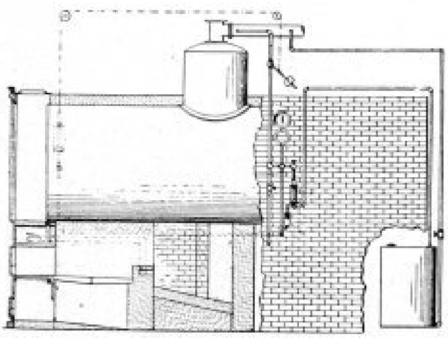
general plane of the sheet, the truss being provided with transverse waves, which impart to it a sinuous form throughout substantially its entire length. One claim.

872,456. BOILER. Lloyd Rowan, of Shawneetown, Ill.

Claim.—A boiler constructed with a cylindrical shell, a series of furnace cylinders in said shell, a shell forming a combustion chamber to the rear of the first-mentioned shell, a series of tube sections arranged at the rear of the combustion chamber, a steam drum extending longitudinally above the shells and tube sections, connections from said shells and tube sections to said steam drum and return flues extending throughout the steam drum. A boiler constructed with a cylindrical shell, a series of furnace cylinders in said shell, a shell forming a combustion chamber to the rear of the first-mentioned shell, a series of tube sections arranged at the rear of the combustion chamber, a steam drum extending longitudinally above the shells and tube sections, connections from said shells and tube sections to said drum. Four claims.

896,411. SMOKE-PREVENTING FURNACE. Arthur W. Puddington, of Cleveland, Ohio, assignor to Robert Rennie, of Toronto, Canada.

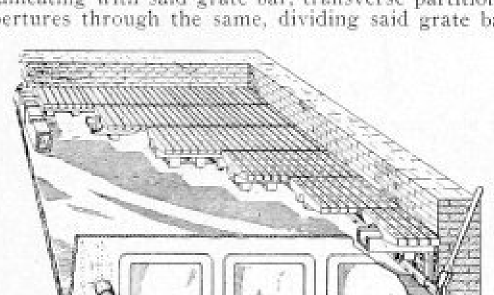
Claim.—In a furnace, a fire-box, an air chamber located above and in front of the fire-box, said air chamber having a



brick roof, a pipe embedded in said roof and a second pipe extending from the pipe in the roof of the chamber through the chamber and terminating in a nozzle, and means for supplying said pipes with a mixture of steam and air under pressure whereby the air is drawn into the fire-box along with the steam and gas. Two claims.

896,692. GRATE. Jackson G. Crowdes, of Boston, Mass., assignor to Charles W. Rugg, of Brookline.

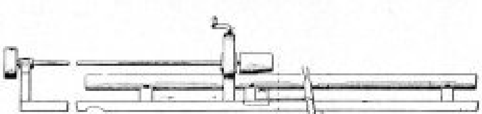
Claim.—In a grate, a hollow grate bar, an air-supply pipe communicating with said grate bar, transverse partitions having apertures through the same, dividing said grate bar into



a series of communicating sockets or chambers, and grate sections seated in said sockets having ducts registering with the apertures in said partitions and provided with perforations in their upper faces leading from said ducts. Five claims.

896,851. TUBE CLEANER. Joseph G. McCarren, of Rockford, Ill.

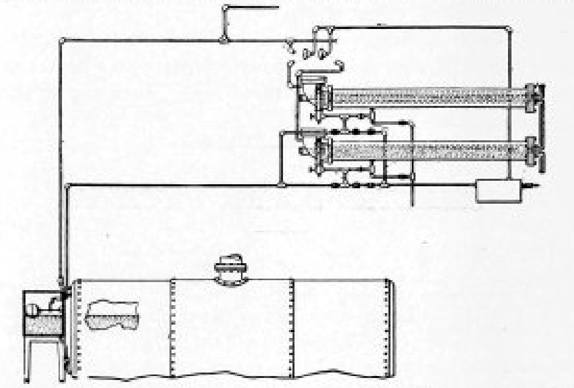
Claim.—A tube cleaner comprising a frame, a head pivotally supported by the frame, two rollers supported by the head, one



located each side of the pivot of the head, means for moving the head on its pivot to reverse the lengthwise movement of a tube supported by the rollers, and a pressure roller located over the rollers of the head. Three claims.

896,820. BOILER FEED. Daniel Goff, of Millville, N. J.

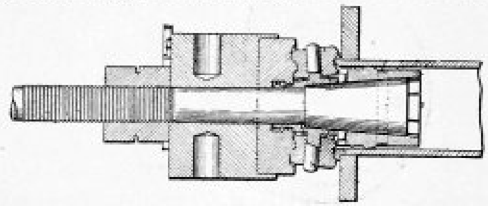
Claim.—A boiler, a plurality of reservoirs, means for conducting water alternately into one or the other of said reservoirs, means for conducting steam from the boiler alternately into one or the other of said reservoirs for forcing the water



therefrom into the boiler, a plurality of cylinders adapted to contain water, a pipe forming a communication between said cylinders, and means for discharging steam from the boiler alternately into one or the other cylinder for forcing the water from one cylinder to the other. Seventeen claims.

897,175. BOILER-TUBE PRESS. Joe Cephus Tassey and James Benjamin Harrington, of Nashville, Tenn.

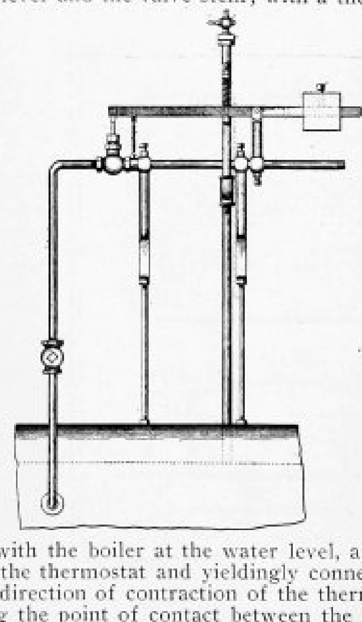
Claim.—In an apparatus substantially as described, the combination of a series of wedges being provided at one end with openings extending radially, a wedge holder in the form of a



ring having at one end projecting lugs adapted to operate in the radial openings of the wedges and having contracted necks, a bolt operating within the series of wedges and having a tapered head whereby to expand the wedges, and co-operating means on the bolt. Five claims.

897,244. THERMOSTATIC BOILER-FEED REGULATOR. Orris O. White, of Garland, Pa.

Claim.—In a thermostatic regulator, the combination of a boiler, a duct, a valve therein, a pivoted lever and connections between the lever and the valve stem; with a thermostat com-



municating with the boiler at the water level, and a rod connected with the thermostat and yieldingly connected with the lever in the direction of contraction of the thermostat, means for adjusting the point of contact between the lever and rod connections, and a spring for holding the said connections in yielding contact. Twelve claims.

THE BOILER MAKER

VOL. VIII NOVEMBER, 1908 No. 11

GUNBOAT BOILERS.

BY CHARLES S. LINCH.

The question is frequently asked, what is a low high-pressure boiler? In reply to these questions the attention of readers of THE BOILER MAKER is called to the drawings herewith shown of the low high-pressure boilers installed on the Wilson Line steamboats, which are in service on the Delaware River between Philadelphia and Wilmington. This type of boiler is more frequently termed a "gunboat" boiler, for the reason that it is frequently used in gunboats or other shallow draft vessels where there is no room between the decks for the ordinary type of Scotch boiler. In the gunboat boiler the furnaces lead to a common combustion chamber, from which the boiler tubes extend to the back head of the boiler. Thus the construction of a gunboat boiler is very similar to that of a Scotch boiler, while the diameter is very much less.

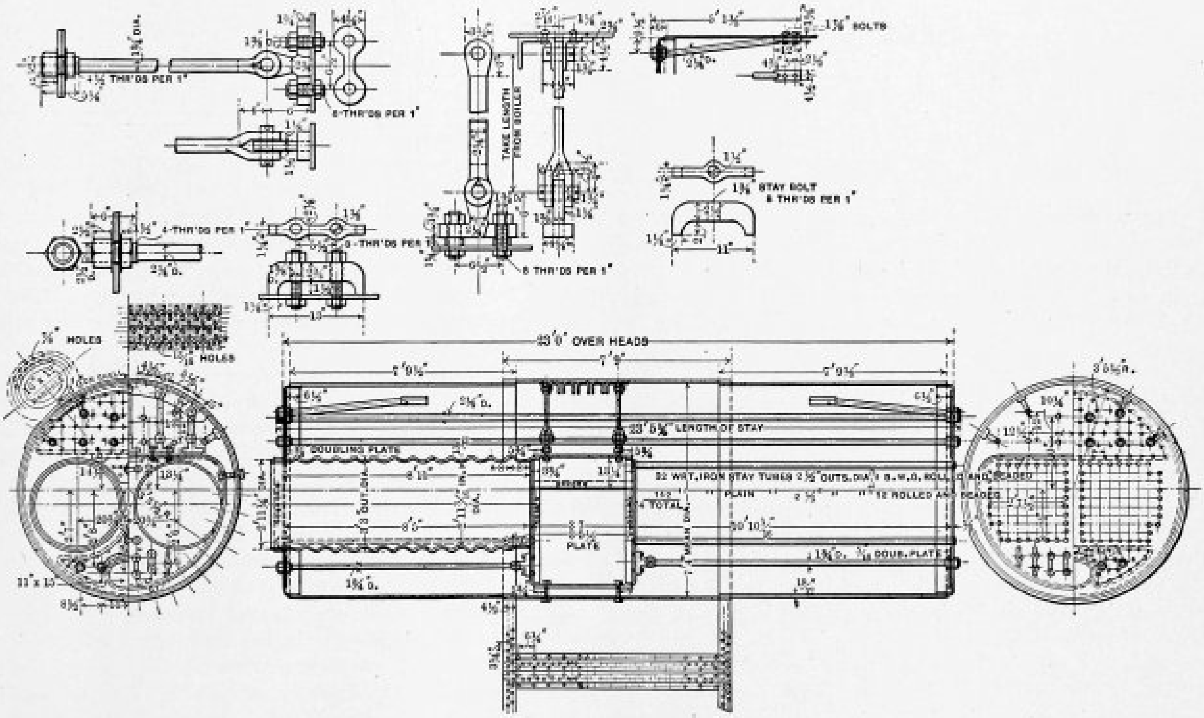


FIG. 1.—DETAILS OF GUNBOAT BOILERS ON THE BRANDYWINE.

The two Wilson line steamers, *Brandywine* and *City of Chester*, were built by the Harlan & Hollingsworth Corporation, at Wilmington, Del., the *Brandywine* in 1883 and the *City of Chester* in 1888. The *Brandywine* is 177½ feet long, with a molded beam of 25.1 feet, and she is driven by a single four-and-aft compound engine, having cylinders 21 and 42 inches in diameter, with a stroke of 24 inches. The boilers originally installed on this boat were in service until 1905, when it was found that the furnaces and combustion chambers would have to be replaced, although the shells were in perfect condition. It was found that the cost of tearing the old boilers out and rebuilding them would be more than the cost of entirely new boilers, and, therefore, new ones were built from similar designs. Plans for these new boilers are shown in Fig. 1. The steam pressure carried on the old boilers was 120 pounds, but when the new boilers were installed this was raised to 150 pounds, and the diameter of the high-pressure cylinder of the engine was reduced to 21 inches, making the ratio of cylinder capacities 1 to 4.

This boat has proved remarkable in many ways. In ten months she recently ran 47,750 miles with a cost for machinery repairs of only 5 cents, this expenditure being for a ¼-inch close nipple. During the summer three round trips are made per day, and in the winter one and a half trips are made daily. Her performance in the ice is considered remarkable, as it has frequently happened that when the ice boats have been unable to cut their way out the *Brandywine* has come through.

The *City of Chester* is 197 feet long over all, with a molded beam of 28 feet and a total beam outside the guards of 40 feet. She is equipped with one three-cylinder triple-expansion engine, with cylinders 18½, 27 and 42 inches in diameter and a stroke of 24 inches. The two boilers which were originally installed on this boat when she was built in 1888 are still in service, and are still carrying the steam pressure of 160 pounds for which they were originally designed. In 1896 the combustion chambers of these boilers were increased 6 inches in length, and suspension furnaces of the Morison type were substituted for plain furnaces. Corresponding to the change in length of the combustion chamber the old tubes were reduced 6 inches in length and were replaced; but, up to the present time, only about one-third of the old tubes have been renewed.

The boilers of both the *Brandywine* and *City of Chester* are operated under forced draft, which is maintained by steam jets of the Bloomsburg type. A Bloomsburg circulator is also used in each boiler. The *Brandywine* is now equipped with a Riley feed-water heater, while the *Chester* takes her feed direct from the filter box. Each boiler is provided with main and auxiliary feed, the main feed pump being a 7 by 4½ by 8-inch Worthington duplex, and the auxiliary feed by injector.

The fuel consumption of both the *City of Chester* and the *Brandywine*, under forced draft, is 35 pounds per square foot of grate area per hour. Under natural draft it is from 20 to 22 pounds.

At the end of the season, when the boilers are opened, the interior is invariably found to be in perfect condition, without the slightest trace of grease, mud, scale or, in fact, any sign of deterioration. This fact accounts for the long life and continued efficiency of these boilers, and is due to the constant attention which they receive by the engineers in charge, since the class of work which these boats do in both summer and winter does not permit the boilers to be opened for months at a time. The machinery in these boats has proved as efficient as the boilers, which is shown in the instance of the packing in the high-pressure and low-pressure stuffing-boxes of the *Brandywine*, which was not touched for twenty-three years, while the piston rods are in perfect condition without a scratch upon them. Further evidence of the class of work turned out when these boilers were installed is shown in the accuracy of the steam gages, which have been in place ever since the boats have been in existence, and which have maintained their accuracy to the present day. These gages were manufactured by the American Steam Gauge & Valve Manufacturing Company, of Boston, Mass.

Although the requirements which these particular boilers are forced to meet are exacting, nevertheless their superiority over any other type of boiler for such service has been well demonstrated. It would be impossible to install Scotch boilers in these boats, as they would encroach upon the deck space which must necessarily be reserved for freight. A careful study of the drawings will serve to show that these boilers are not only strong and well built, but that the steam space is large as compared to that of many Scotch boilers; that is, the ratio of the volume of the steam space to the volume of the high-pressure cylinder is large. Trouble from leaky seams has not been experienced with these boilers, due probably to the fact that water circulators are fitted. The frequent claim that the low high-pressure or gunboat type of boiler is an inefficient steam generator and a poor design to use has been entirely discredited in the case of these two boats.

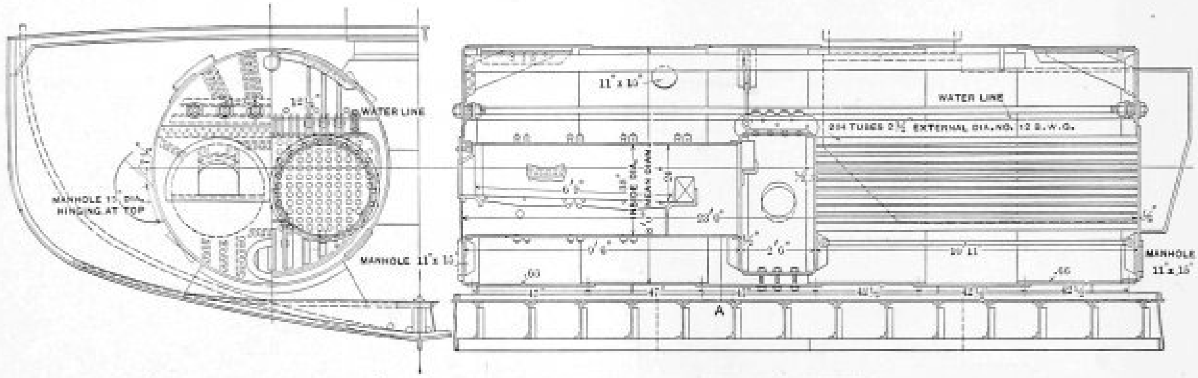


FIG. 2.—ONE OF THE GUNBOAT BOILERS ON THE CITY OF CHESTER.

BOILERS OF THE "BRANDYWINE."

The boilers of the *Brandywine*, details of which are shown in Fig. 1, are 23 feet long, 7 feet 4 inches in diameter, built for a working pressure of 150 pounds per square inch. The total heating surface is 1 405.9 square feet, divided as follows: Tubes, 1,234 square feet; furnaces, 98.4 square feet; combustion chamber, 58.5 square feet; tube plate, 15 square feet. The total grate surface is 39.5 square feet, making a ratio of heating surface to grate area of 35.5 to 1. The area through the tubes is 703 square inches per square foot of grate area.

The shell of the boiler is in three courses, and is 19/32 inch thick. The circular seams are double-riveted lap joints, with ⅞-inch rivets spaced 3¼ inches between centers. The longitudinal seams are triple-riveted butt joints, with the outside straps ½ inch thick and 9 inches wide, and the inside straps 14¼ inches wide and ½ inch thick. The rivets are ⅞ inch diameter, and are spaced 3⅛ inches and 6¼ inches between centers. The percentage strength of this joint, as compared with the solid plate, is 85.8.

Each boiler has two corrugated furnaces, 3 feet 3 inches outside diameter, 8 feet 11 inches long, 13/32 inch thick; and 174 2½-inch outside diameter tubes. Thirty-two of the tubes are wrought iron stay tubes, No. 9 B. W. G.; the remaining 142 are wrought iron plain tubes, No. 12 B. W. G. The distance between tube plates is 10 feet 10 1/16 inches.

The front head of the boiler is a single sheet, ½ inch thick, flanged inwards to join the shell and outwards for the furnace mouth. The portion of the head above the furnace is reinforced by a ⅜-inch doubling plate, and the portion below the furnace by a 5/16-inch doubling plate.

The heads of the boiler are stayed by 2¼-inch through stay rods and 2¼-inch diagonal stays. The lower part of the heads is braced by 1¾-inch stay rods, fastened to the combustion chamber by two 1⅜-inch bolts, as shown in the details, Fig. 1. The staying of the combustion chamber crown sheet is accomplished by means of sling stays to the shell of the boiler, spaced 6 inches longitudinally and 6½ inches across the boiler. These stays are fastened to the crown sheet so as to leave a clear water space of 1¼ inches all over the sheet.

BOILERS OF THE "CITY OF CHESTER."

The two boilers of the *City of Chester* are each 23 feet long and 8 feet diameter. Each boiler has two plain circular furnaces, 38 inches inside diameter and 9 feet 6 inches long, with a single combustion chamber, 2 feet 6 inches deep and 204 2½ inches outside diameter tubes of No. 12 B. W. G. thickness. The total heating surface in each boiler is 1,644.5 square feet, divided as follows: Flues, 109.5 square feet; combustion chamber, 58.5 square feet; tubes, 1,457.5 square feet; back tube sheet, 19 square feet. The grate area of the boiler is 42.75 square feet, therefore the ratio of heating surface to grate area is $\frac{1,644.5}{42.75} = 38.5$ to 1. The flue area through the tubes is 5.8 square feet, and the ratio of the area of the grate surface to the area through the tubes is $\frac{42.75}{5.8}$, or 7.37 to 1.

The boilers were designed for a working pressure of 160 pounds per square inch. They were built of six courses of steel plate .66 inch thick. The circular seams are double-riveted lap joints, fastened with 1-inch rivets spaced 3½ inches between centers. The longitudinal seams are triple-riveted butt joints with steel butt straps, ½ inch thick, fastened with 1-inch rivets spaced 4½ inches between centers. The front head is made in two sections, the furnace sheet and the upper sheet. These are fastened together with a lap joint by ⅞-inch rivets spaced 2½ inches. Both sheets are ½ inch thick, and the furnace sheet is flanged inwards at the furnace mouth.

The furnaces themselves are plain cylindrical tubes of ½-inch plate, with single-riveted lap longitudinal joints, fastened with ⅞-inch rivets spaced 2½ inches between centers. The furnaces are stayed by means of iron rings, 3 by 1½ inches half round at the top and flat on the bottom. On the upper part of the furnace, above the grate bars, these reinforcing rings are separated from the furnace by thimbles around the rivets 1¼ inches long, leaving a clear water space outside the furnace. On the bottom of the furnace, however, these reinforcing strips are riveted fast to the plate without the intervening water space. There are four reinforcing rings on each furnace. The grates are each 6 feet 9 inches long, and terminate at a soapstone fire wall. A similar wall is also placed at the top of the furnace at the entrance to the combustion chamber, in order to protect the crown sheet thoroughly.

The combustion chamber tube plate is ½ inch thick, and is flanged inwards to join the wrapper sheet. The crown sheet is stayed by the ordinary form of girder crown bars, carrying stay-bolts 1⅜ inches diameter outside the threads and spaced 6 inches apart. The girders themselves are spaced 6¼ inches center to center. Each girder is composed of two ¾-inch plates, 6½ inches wide. The sides and bottom of the combustion chamber are supported by 1⅜-diameter threaded stay-bolts, spaced 6¼ inches circumferentially and 6¾ inches longitudinally. These stays are fitted with nuts, both outside the boiler shell and inside the combustion chamber.

The heads of the boiler are stayed partly by means of through stay rods of double refined iron, 2¼ inches in diameter, and partly by gusset stays of ⅝-inch plate, 10¼ inches wide, riveted to the shell and to the head by double 5 by 3 by ½-inch angle bars. Details of the method in which the through stays are fastened to horizontal angle bars on the heads are shown in the drawing.

The capacity of the steam space in a horizontal tubular boiler is frequently made equal to the volume of steam used by the engine in 20 seconds.

Apprenticeship Training.

Each year a committee of the Master Mechanics' Association presents an exhaustive report covering the progress made in the development of apprenticeship systems for railroad shops. The report this year was presented by Mr. C. W. Cross, of the New York Central & Hudson River Railroad, and in substance is as follows:

Your committee, recognizing the fact that there is a wide difference in organization and local conditions as to available material and facilities for instruction, considers that a hard-and-fast general apprenticeship code is impracticable, and, therefore, suggests the discarding of the code adopted in 1898 and the substitution of basic principles rather than a formal code.

To assure the success of the apprenticeship system, the following principles seem to be vital, whether the organization is large or small:

First. To develop from the ranks in the shortest possible time, carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

Second. A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and, in close connection therewith, should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory and conducted during working hours, at the expense of the company.

Third. Apprentices should be accepted after careful examination by the apprentice instructor.

Fourth. There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for apprenticeship who may be better prepared as to education and experience than is expected of the usual candidate.

Fifth. Suitable records should be kept of the work and standing of apprentices.

Sixth. Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

Seventh. Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

Eighth. It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibilities.

Ninth. Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

Tenth. Apprenticeship should be considered as a recruiting system, and the greatest care should be taken to retain graduated apprentices in the service of the company.

Eleventh. Organization should be such as graduated apprentices can afford to enter for their life-work.

For the purpose of obtaining data as to the conditions on various roads of the country, information was secured which is summarized as follows:

1. A shop plant for the purpose of this report is one in

which general repairs of locomotives or cars are made. Fifty-five roads report 301 shop plants having apprentices.

2. Fifty-five roads report sixty-seven shop plants in which there are no apprentices.

3. Fifty-five roads report a total of 7,053 apprentices in shop plants.

4. Fifty-five roads report apprentices in each trade as follows:

Machinists	4,814
Boiler makers	952
Blacksmiths	311
Patternmakers	64
Cabinetmakers	22
Tinners-pipefitters	365
Molders	82
Electrians	14
Painters	137
Upholsterers	27
Carpenters	249

5. Reports from fifty-five roads show the average ratio of apprentices to mechanics in each trade to be follows:

Machinists	1 to 4.8
Boiler makers	1 to 6.8
Blacksmiths	1 to 13.9
Patternmakers	1 to 3.3
Cabinetmakers	1 to 23.3
Tinners-pipefitters	1 to 5.1
Molders	1 to 8.2
Electrians	1 to 8.6
Painters	1 to 19.2
Upholsterers	1 to 11.3
Carpenters	1 to 72.4

6. The majority of replies indicate difficulty in securing apprentices in some of the trades, but no difficulty in others. A few replies state no difficulty in securing apprentices. This is apparently due to local conditions.

7. Out of a total of fifty-five replies, ten, or 18.2 percent, indicate special instruction in trades is given apprentices. Forty-five replies, or 81.8 percent, do not provide for special instruction.

8. Out of a total of fifty-five replies, sixteen, or 29 percent, indicate an established school system, and thirty-nine, or 70.9 percent, have no school system.

9. Out of a total of fifty-five replies, thirty-nine, or 70.9 percent, have apprentices and no school system, and eight roads state that they intend to establish such a system.

10. Eighteen replies favor day schools, and three, or 14.3 percent, favor night schools out of a total of twenty-one replies.

11. Fifteen replies show thirty-seven schools with 1,567 apprentices attending. The majority of the schools were recently established.

12. Of the above schools, twenty-eight are held in working hours and nine are held in the evening.

13. Of the above schools, thirty-four are compulsory and three are optional.

14. Out of fifty-five roads, twelve pay the apprentices for time spent in school.

15. Modern apprenticeship training has been introduced in seventeen shops on four roads with 506 apprentices since the convention of June, 1907. The following roads and systems of roads have made substantial progress in this work:

Union Pacific—Two schools, one at Omaha and one at Cheyenne; the former established Sept. 1, 1906, 71 apprentices; the latter established Dec. 1, 1907, 21 apprentices.

Michigan Central—One school at St. Thomas; established Dec. 1, 1907; 36 apprentices.

Santa Fe—Ten schools, established 1908; 363 apprentices.

Southern Railway—Two schools, one at Knoxville, Tenn., established 1907; and one at Spencer, N. C., established 1907.

Delaware & Hudson—Three schools; located at Green Isle, Oneonta and Carbondale; established 1907; 86 apprentices.

Substantial progress has also been made on roads having schools previously established, on the Grand Trunk Railway, Central Railroad of New Jersey, Boston & Maine Railroad. Union Pacific Railroad, Minneapolis, St. Paul & Sault Ste. Marie Railroad, and New York Central lines.

The Canadian Pacific Railroad and the Erie Railroad advise they intend to install the improved plan of apprenticeship during the present year. Other important roads have the subject under contemplation.

These replies cover apprenticeship which is both new and old, some of the statements coming from roads of many years' experience.

The new apprenticeship, which combines instruction in the trade with mental training, is progressing rapidly on railroads, as described in answers to question 15.

The results of these questions show how large a field is available for the new apprenticeship, as well as illustrating the extent of the present development.

Your committee believes that the strongest part of this report is embodied in the practical exhibit of apprentice training and methods. This exhibit illustrates the development of the several roads in this matter up to date. The exhibit is worthy of most careful study, and your committee believes that the exhibit itself speaks in a far more definite and practical way of the details of the methods which are being employed than could possibly be put into words in even a very long report.

Your committee recommends that the association provide an appropriation for establishing an exhibit of apprentice training to be a feature of each convention.

It has often been said that apprenticeship is a thing of the past. This certainly is not true of American railroads to-day, where a new apprenticeship has sprung up and has attained a healthy growth with brightest promise for the future. Your committee does not hesitate to characterize the new apprenticeship as the most important influence introduced into railroad organizations during the present generation. This development is sure to be rapid, requiring great wisdom, combined with conscientious and systematic efforts in its control. We believe this movement will become the most powerful influence in supplying and preparing the men of the future for the motive power departments (and perhaps other departments) of American railroads; because the movement trains men in the ideal way, and because men properly prepared for their work constitute our greatest problem to-day.

RECENT PROGRESS OF APPRENTICE TRAINING IN ENGLAND.

Manufacturers and railroad managers in Great Britain have long been alive to the apprentice situation and have developed a number of successful systems embodying advanced and novel ideas. The subject has been given more careful consideration and fuller discussion than in this country, and that more general results have not thus far been produced is probably due to the natural conservatism of an older community and to the hereditary idea of class or caste, evidenced in the retention of many firms of the premium apprentice, a young man paying for the opportunity of entering the shop and usually given special privileges in learning the business. There still remain also, in many cases, long-term apprenticeships of from five to seven years.

The British system of evening technical schools is such that each manufacturing center may be said to have its "Cooper Union." These district technical institutes, as they are called, are usually maintained jointly by grants from the educational board, by railroads and manufacturers, and to a small extent by the nominal fees charged for instruction. The use of such schools by firms having apprentices is quite general.

Several establishments make it a practice to excuse apprentices for six months of each year for attendance at day technical schools, crediting the time lost on the apprentice term, but it should be remembered that in such cases the apprenticeship is usually seven years. Both railroads and manufacturers appear to be united in placing emphasis on the value of technical education, and the offering of prizes for high scholarship in evening classes is a common practice.

The Lancashire & Yorkshire Railway has built a mechanics' institute at Horwich, a point which is the location of large shops. Apprentices are supposed to attend evening classes at a nominal fee, and as a reward for progress thirty boys are selected each year for free instruction during company time for two half-days per week. The teachers are mainly from the railway company, and the character of the instruction is such that many outsiders take the course, paying increased fees.

The Great Western Railway has day and evening courses with engineering and trade classes in the local technical school at Swindon. About 45 percent of the apprentices attend these classes. After one year in shop, apprentices may compete for day scholarships, consisting of instruction for two half-days weekly, extending over twenty-six weeks per year for three years, the railroad paying wages for the time spent at school, also the school fee. The subjects taught are practical mathematics, practical mechanics, geometrical and machine drawing, heat, electricity and chemistry. The number of scholarships at any one time is limited to thirty. In addition a limited number of apprentices are allowed to attend day classes two afternoons per week of three hours each, without pay, and paying their own school fee. Apprentices taking full evening courses have the liberty of being late for shop the following morning.

For over sixty years the London & Northwestern Railway has maintained the Mechanics' Institute at Crewe, where, out of a population of 45,000, there are 8,500 men in the railroad shops and round-houses, besides many in other departments. Schooling is optional except with electrical apprentices, who are paid wages for one afternoon per week instruction. Prizes are offered by the company for progress in evening classes, which are taught, as a rule, by employees. The classes are open to outsiders, but employees are admitted at reduced fees.

One of the latest movements among manufacturers is that of Messrs. Clayton & Shuttleworth, who in February, 1907, decided "to graft the advantages of the bygone system upon the so-called factory system of modern times." The aim was first to supplement shop work with courses of instruction directly bearing on the work in the shops; and, second, to give all deserving apprentices a varied shop experience. The movement through the shops was to depend on the proficiency of the apprentices. The firm was to maintain its own school in working hours, furnish books and material free. A superintendent was to give full time to the apprentices. The apprentice regulations allow apprentices to enter between the ages of fifteen and twenty-two—sixteen to eighteen preferred—and offer a choice of eight trades. Machinists and pattern-makers entering at eighteen serve three years. Molders, blacksmiths and boiler makers entering at eighteen serve four years. Schooling is compulsory in all cases. The aim is to make mechanics, but those showing ability to go higher will be given the opportunity. After twelve months of operation with fifty apprentices, the management reports slightly increased cost of production, but expects compensation in future benefits.

Another interesting system is that of Messrs. Brunner, Mund & Company, who in 1884 started voluntary evening class attendance at the public school, but soon made the attendance compulsory, and offered prizes to those attending 75 percent of the time. In 1904 school attendance was made compulsory for nine-tenths of the possible evening classes, and the rule was made to apply not only to apprentices but to other employees under nineteen. Since 1905, apprentices with three years' good record in evening class have been given two-year day courses—two afternoons a week under full wages. The report states that "this system was not commenced as a work of philanthropy, but as a matter of business." The work manager says: "Up to the present we have gained (1) a better understanding of mechanical drawing; (2) greater ability in setting up work. Up to a few years ago, few mechanics understood a drawing—now many of our lads show great ability in hand sketching, placing their measurements on paper in an understandable form. It used to be the most difficult of all things to teach an apprentice to set up his work, but now in many cases it comes to him naturally. I consider that our younger generation of mechanics show a marked improvement, both in ability and keenness for work, and it is a pleasure to deal with many of them on account of the interest they display."

Out of a list of fifteen described in recent issues of the *Engineer* (London), seven make a practice of sending the most promising boys, while under pay and at the company's expense, to day classes for one or two days per week. The classes in most cases are at neighboring technical schools, and the selection of apprentices for the day scholarships is usually based on competitive work in the evening classes. Eleven of the fifteen manufacturers advise apprentices to attend evening classes, and three make such attendance compulsory. When an English firm intends to pay the school fees the accepted method appears to be for the apprentice to first pay the fee and later be reimbursed by the firm if he makes satisfactory progress or attends a sufficient percentage of classes.

Several grades of classes of apprentices are maintained by the British Westinghouse Company and by Yarrow & Company, including a special classification for technical graduates.

The North-East Coast Institution of Engineers & Ship Builders have recommended a system of marks for apprentices, to include the attendance, industry and advancement in evening study, and the behavior and efficiency in the shop. Those apprentices reaching a given percentage of marks are rewarded by increased wages and by special opportunities for advancement. The scheme is designed to foster self-help, and has been applied by several manufacturers.

A departure in student-apprenticeship courses has been made by the Sunderland Technical College. These courses, which were started in 1903, are open to apprentices in ship-building and engineering shops who are under eighteen years of age, who have already served two years in the shops, showing ability and giving satisfaction, and who have attended evening classes for at least two years. Boys are allowed leave of absence from the shops from Oct. 1 to March 31 of each year to attend the college, the time counting on the apprenticeship term. A combination diploma is given, signed by the firm, by the college and by the Association of Ship Builders and Engineers of Sunderland and District. The suggestion has been made that these courses be extended for nine months, with classes repeating each two weeks, thus giving short alternating periods in shop and school, not unlike the idea being carried out in the United States by the University of Cincinnati.

Evening classes versus day classes is already arousing discussion in England. Evening classes have failed to produce the expected results. In a recent paper on the subject one investigator says that a large amount of evening instruction is wasted, and recommends that evening schools give assistance to enable a few to train themselves above the average, rather than trying to produce a light crop over a large area and attempting to reach the rank and file. The statement is further made that only a very exceptional youth, strong both mentally and physically, can make any great headway by evening study and at the same time work regularly and well in the shop from 6 A. M. to 5 P. M. In this connection the experience of Messrs. Cochran & Company is instructive. In 1903 a three-year course of evening apprentice instruction was started, but in 1905 this was changed to day classes, holding sessions from 8 A. M. to 10 A. M. without deduction of wages. The results have been all that could be wished, and the coaxing previously necessary to make boys attend evening class is no longer needed. Prizes are given boys who apply the school training in the shop. Messrs. Cochran & Company report a direct benefit in the shop due to school work.

In conclusion it might be mentioned that nearly all the firms who are attempting to solve the apprenticeship question have abandoned the premium apprentice. Attention should also be called to the fact that there is but little reference to methods of handling the shop side of the question, and no mention of shop instructors in connection with any of the roads or manufacturers, and it would, therefore, appear that the problem in Great Britain has been considered almost entirely along educational lines and hardly at all in the shop.

Boiler Explosions, Collapses and Sundry Mishaps.

British Board of Trade reports concerning boiler explosions for 1907 record the occurrence of seventy-seven explosions, collapses and mishaps of various kinds, resulting in the death of twenty-eight people and injuries to fifty-eight others. Of these, eight, causing eight deaths, were explosions, and two, without fatal consequences, were collapses of furnaces or flues in land or stationary boilers; two, also unattended by loss of life, were explosions of heating apparatus; eight, causing three deaths, were collapses of furnaces or combustion chambers afloat; while thirty-four, causing fifteen deaths; and twenty-three, causing two deaths, were mishaps of various kinds on shore and at sea, respectively.

The curves in Figs. 1 and 2 give a graphic record of the number of boiler explosions in Great Britain since 1859 in case of land boilers, and since 1882 for marine boilers. In each case the number of explosions is represented by a solid line, the number of collapses by a dot-and-dash line, and the number of sundry mishaps by a dotted line. It will be seen that the total number of boiler failures has decreased, rather than increased, since these records were kept, notwithstanding the fact that the number of boilers in use must have increased enormously. From Fig. 1 it is seen that whereas in the earlier years most of the failures were explosions, in later years the number of explosions has been reduced to a very small quantity. This clearly shows the benefits of the rigid and thorough system of boiler inspection which prevails in England, since most of the defects in boilers are discovered

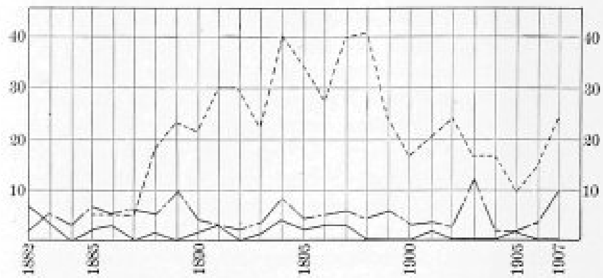


FIG. 2.—DIAGRAM SHOWING NUMBER OF EXPLOSIONS OF MARINE BOILERS SINCE 1882.

and repaired before the condition of the boiler has become so bad as to result in an explosion. Such failures, therefore, are classed in the reports as sundry mishaps, which usually are not attended with fatal consequences.

Similar conditions exist with respect to marine boilers, except that the inspection on board ship has always been more careful than in stationary practice, and the number of explosions has never been as great per thousand horsepower as on land.

Comparing the record of seventy-seven explosions, twenty-eight deaths and fifty-eight injured, which occurred in England, with the record of 471 explosions, 300 killed and 420 injured in the United States for the year 1907, the need of adequate boiler inspection in this country is clearly shown, notwithstanding the fact that there are undoubtedly many more boilers in use in this country than in England. Statistics showing the relative number of boilers in use in England and the United States would be of great value in making a comparison between the effects of thorough and careful inspection in England and the lack of such a system in this country; but, unfortunately, such statistics are not available, and so the reader must draw his own conclusions.

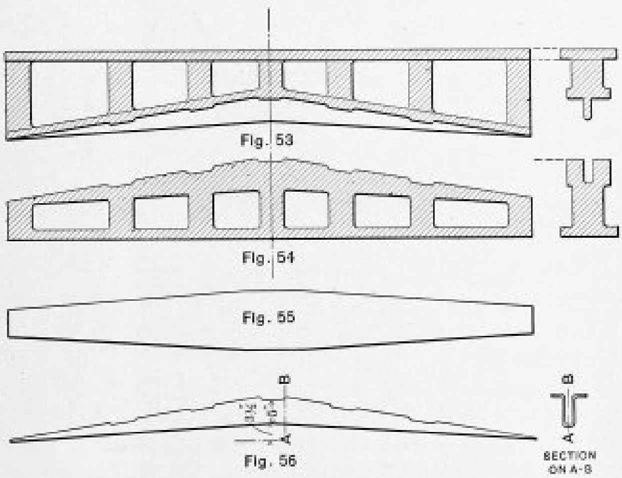
FIG. 1.—DIAGRAM SHOWING THE NUMBER OF BOILER EXPLOSIONS ON LAND IN GREAT BRITAIN SINCE 1859.

Flanging Boiler Plates.—V.

BY JAMES CROMBIE.

Light Flange Press Work.

One of the most interesting pieces of work which engages the attention of those in charge of boiler shops is that of pressing or flanging light sheets in suitable machines in one or two operations. Where large flanges are required, or shapes have to be pressed to any depth, there will necessarily be a large amount of metal to be disposed of. This excess metal will gather and buckle up or crimp if provision has not been made to allow it to upset as it is being formed into the required shape. During the past few years the uses to which pressed sheet steel has been put are almost numberless. It is coming into every walk of life—in the office, as stools and fixtures; in the streets one finds pressed steel horse collars, wheelbarrows and drag-scrapers, with the bowl pressed from one sheet; in the home the old cast-iron sink is giving place to the pressed steel kitchen sink, and the bath-tub is also being pressed from one sheet of steel.



DIES AND PLATE FOR PRESSED STEEL CAR ROOF BEAM.

Many operations can be performed on the hydraulic press without the use of a drawing die, but where an object requires a deep flange a drawing or clamping die will have to be used, so that the stock will partly upset before entering the forming dies. The sheet is held around the outer edge by the clamping dies; then when the pressure is applied to the male, or forming die, and the sheet is undergoing the process of formation, it is gradually pulled from between the clamping dies. The excess metal is gradually upset just previous to leaving the clamping dies. In this way it is impossible for the metal to buckle over and tear. If the sheet is to be pressed to any depth it will require heating several times, owing to the thin sheet being chilled in the dies.

Fig. 53 shows the male die and Fig. 54 the female die for pressing a beam for a car roof. The plate is 110 inches long and 3/16 inch thick, and is pressed to a depth of 5 inches, with a flange on either side, five recesses being formed in either flange. Fig. 55 shows the plate and Fig. 56 the plate after it is pressed into shape. This is pressed in a large four-column press; the male die is bolted to the top of the press and the female die to the moving platen. The sheet is heated, then laid on the female die; pressure is applied to the moving platen, which quickly ascends and presses the sheet into shape in one operation. To look at the finished sheet one would think it was a very difficult piece of work, but it is really a simple piece to flange, does not require clamping dies, and requires less than one minute from the time it leaves the furnace until it is laid aside finished.

There are few light sheets on a boiler. In Chapter IV., in Fig. 51, there is shown the dome casing top, No. 15. This

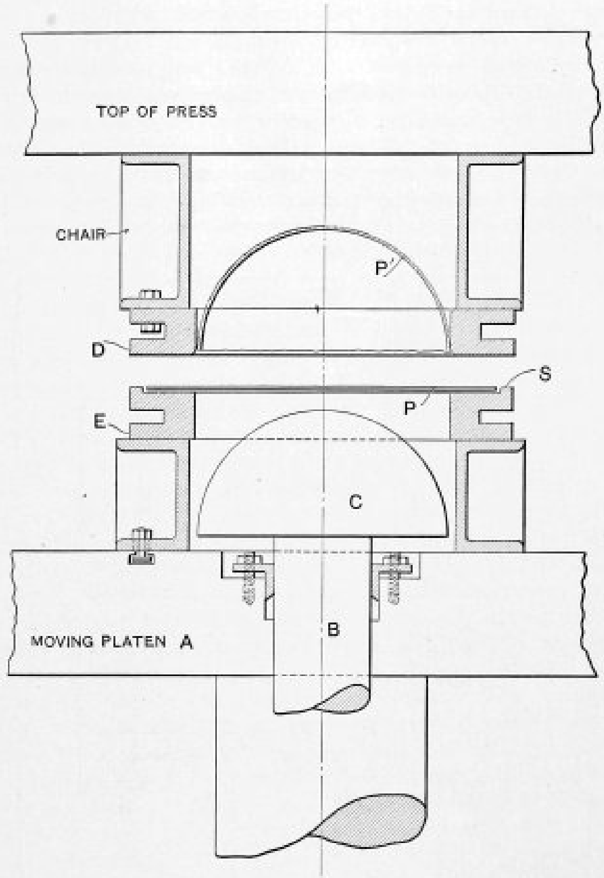


FIG. 57.—DIES FOR FLANGING A DOME CASING TOP.

sheet is ⅛ inch thick, and is pressed to a depth of from 12 to 16 inches. A description of the flanging of this sheet will serve to illustrate the use of the clamping dies. At Fig. 57, *A* is the moving platen, with an internal ram *B*. To the ram *B* is suitably affixed the former *C*; *D* is the female forming die, and *E* is the clamping, or holding, die; on this die there should be three or four stops, as at *S*, 1/16 to ⅛ inch thicker

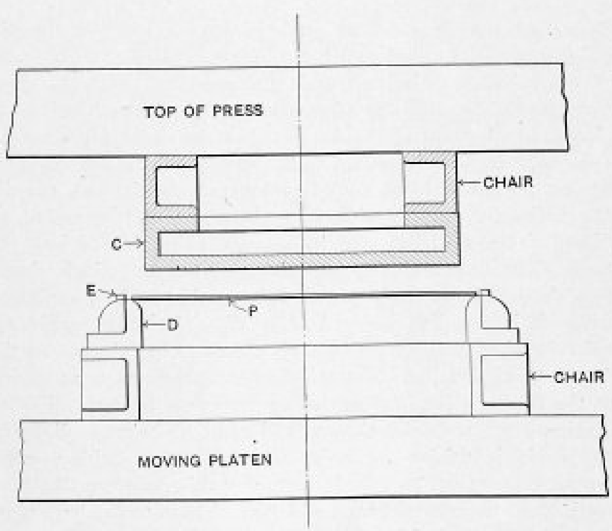


FIG. 58.—DIES FOR FLANGING TANK HEADS.

than the sheet to be pressed. These stops take up the thrust of the press, leaving an easy space for the sheet to be drawn through. The sheet is heated and laid on the die *E* as at *P;* the pressure is then applied to the main ram, raising the moving platen *A* until the dies *E* and *D* come together; pressure is then applied to the central ram *B,* which raises the former *C* against the plate *P,* forcing it from between the dies *D* and *E* up through *D.* At *P'* the sheet is shown almost finished. This dome casing will require two heats to bring it into shape, as there is a larger amount of metal to upset.

Fig. 58 shows the die required to flange tank heads. These are 30 inches diameter, No. 9 gage, and are flanged cold. They are pressed clear through the die *D,* and drop on the table finished, and are taken out at the bottom. The sheet *P*

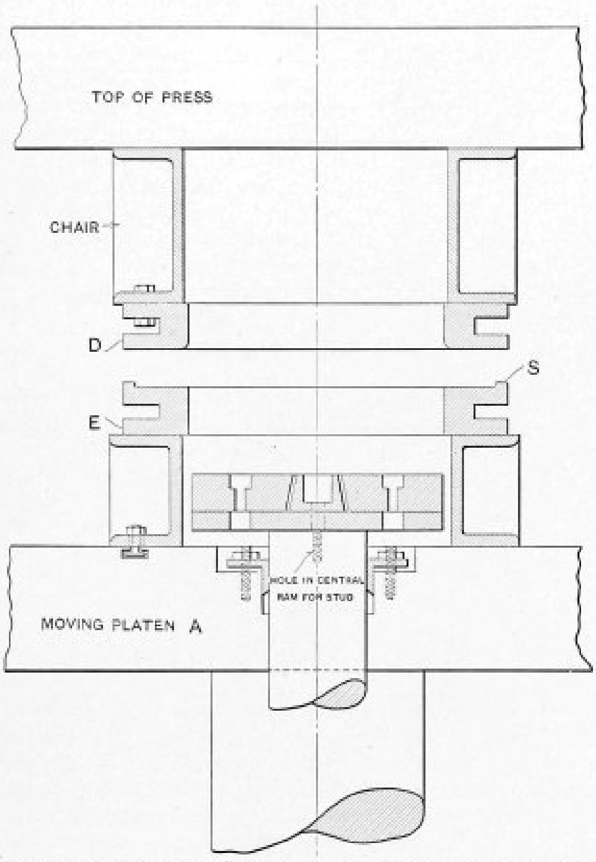


FIG. 59.—RELEASING DIE FOR TURNING DEEP FLANGE ON TANK HEADS.

is laid on the die *D;* four guide pieces, as at *E* on the die, quickly center the sheet, pressure is then applied and the lower platen raised, causing the male former *C* to press the sheet through the die until the edge of the newly-formed flange has cleared the bottom of the die *D,* when the sheet will drop off finished. It will be noticed that the sheet is not clamped against the male former while being pressed through the die *D.* This causes the head to leave the dies nicely rounded, or dished, instead of flat, and looks well when riveted into the tank. The flange of this head is for 5/16 or ⅜-inch rivets. If a deeper flange were required it would not be possible to flange it in the dies shown in Fig. 58. The sheet would require heating, and would be flanged somewhat similar to the dome casing, Fig. 57, using a different male former, as, owing to the head cooling and shrinking, it would be impossible to get it off the male die shown in Fig. 58. The male die, Fig. 59, would in this case consist of a base plate, with a small central cone to act as a wedge; around this cone are the three sections of the male former, which are bolted to the base plate through oblong holes. When this sectional male die is relieved from the pressure, the ram and cone will descend, and the sections will also respond, leaving the flanged head sticking in the female die, from which it will quickly fall as it cools. If the head requires to be dished a piece of plate the required shape can be placed on top of the male die. This will dish and flange the head at the same time.

In hydraulic press work care must be exercised in the use of the water. It requires steam to drive the pumps which

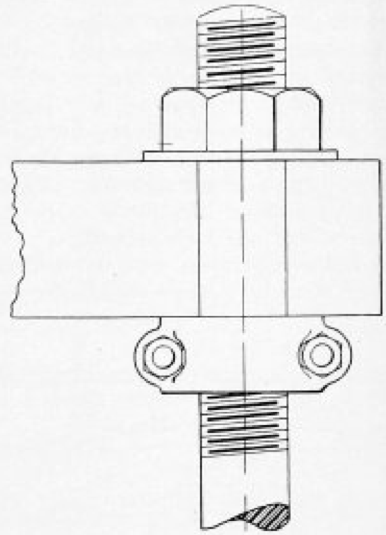


FIG. 60.

raise the accumulator, and thus supply the power to the press. Steam means fuel, and fuel means dollars and cents. In the four-column press the top table is supported on large nuts, other nuts being on the top to take up the thrust when the pressure is applied, Fig. 60. These nuts can be slackened, allowing the table to be raised or lowered to accommodate

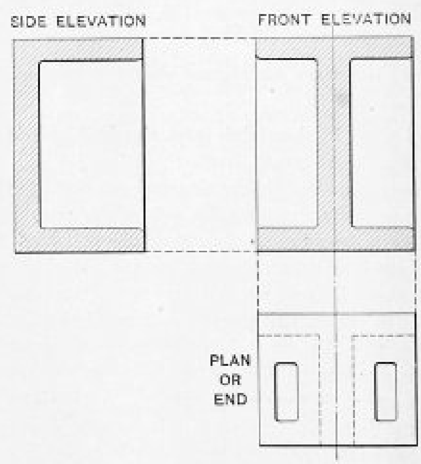


FIG. 61.—CHAIRS FOR LESSENING TRAVEL OF RAMS.

the size of the job; the purpose is to have the dies as close as possible, to save needless travel of the rams.

An ordinary press will have about 3 feet of travel on the main ram and also 3 feet on the internal ram; then the moving platen and the top of the press will be 6 feet apart; if the dies were bolted direct to the table, and a piece requiring the operation of both rams had to be flanged, the accumulator would drop 10 or 12 feet, and before another sheet could be flanged the operators would have to wait until the pumps had raised the accumulator to the top again before flanging the other sheet

To prevent waste of fuel, and also waste of time in moving these nuts and lowering the table, suitable chairs should be used between the dies and the table, as shown in Fig. 61. They are made in different heights, and have cored holes for bolts. They also allow a reduction in the weight of the dies.

Manufacture and Testing of Steel Material Intended for Boilers Under the British Board of Trade Survey.

The marine department of the British Board of Trade have had under consideration the reports issued by the engineering standards committee relating to structural steel for marine boilers, ingot steel forgings for marine purposes, and steel castings for marine purposes; and have prepared the following amended instructions for the guidance of their surveyors. These instructions went into effect on Aug. 1, 1908:

GENERAL CONDITIONS.

All steel intended for use in the construction of boilers and for forgings shall be made by the open-hearth process. Boiler plates shall be of acid quality; but the other portions of boilers and forgings may be made of either acid or basic steel. In the case of castings, the steel may be made by any process which has been approved by the Board of Trade. The finished material shall be sound and free from cracks, surface flaws and laminations. No hammer-dressing, patching, burning or electric welding is permissible, and if any material is annealed or otherwise heat-treated, the test pieces shall be similarly and simultaneously treated with the material before they are tested. No further heating or forging of the specimens may be done, and all the necessary preparation shall be made in a machine.

All the test pieces required shall be selected by the surveyor, and, except where otherwise specified, the tests shall be made in his presence at the place of manufacture, and before the despatch of the material; and the stamping of test pieces shall be done after all the heating or annealing is completed. When a number of articles are cut from one plate, bar or forging, the number of tests required shall be the same as that required from the original piece, provided the articles have not been further heated or forged and can be identified as having formed part of the original piece. When a number of small forgings are made from the same ingot, or a number of small castings from the same charge of steel, the full number of tests specified herein need not be made; tensile and bending tests at the rate of one of each for every four articles will, as a rule, in such cases be sufficient. Should either a tensile or a bend test fail to fulfil the test requirements, and the surveyor considers that the test piece does not fairly represent the quality of the material, two duplicate specimens may, if the maker wishes, be tested; and if the results obtained from both are satisfactory, the quality of the article shall be judged therefrom and not from the original test which failed. If, however, either of the duplicate tests fails, the article or articles represented shall be rejected.

Every article shall be stamped with a number or identification mark, such that the charge of steel from which it was made can be readily identified. In addition to this plates and bars shall be stamped with the maker's name or trade-mark, and plates with the results of any tests which are made from them. In the event of any material proving unsatisfactory in the course of working or machining, it shall be rejected, notwithstanding any previous certification of satisfactory testing.

STEEL FOR USE IN BOILERS.

The following instructions refer to steel of ordinary mild quality: Where special or high tensile steel is used the requirements specified by the board in each case shall be adhered to. Should any tensile test piece break at a point outside the middle half of its gage length, the test may, at the maker's option and with the surveyor's approval, be discarded, and another test made from the same plate or bar.

Plates.—A tensile and a bending test shall be taken from each plate, as rolled; but when the weight of the plate exceeds 2½ tons, a tensile and a bending test shall be taken from each end. Bending tests only need, however, be made from plates for which a greater stress than is allowed for iron is not wished. The bending tests of plates not intended to be worked in the fire or exposed to flame may be made with strips in the same condition as the plates; those from other plates should be made with strips which have been tempered.

Test specimens may be cut from the plates, either lengthwise or crosswise, and, whenever practicable, the rolled surfaces shall be retained on two opposite sides of the test piece. In all cold and temper bend tests of samples .5 inch in thickness and above, the rough edge caused by shearing may be removed by filing or grinding; and samples 1 inch in thickness and above may have the edges machined. For temper bends, the samples should be heated to a blood red and quenched in water at a temperature not exceeding 80 degrees F.

The tensile strength of plates not intended to be worked in the fire or exposed to flame, for which special limits have not been sanctioned, shall be between 27 and 32 tons per square inch; that of other plates, from 26 to 30 tons per square inch. The elongation shall not be less than 20 percent in a length of 8 inches for material .375 inch in thickness and upwards which is required to have a tensile strength of 27 to 32 tons per square inch, and not less than 23 percent if the tensile strength is required to be between 26 and 30 tons per square inch. For material under .375 inch in thickness, the elongation may be reduced; but for each eighth of an inch of diminution in thickness, the reduction shall not be more than 3 percent below the elongations named above.

Bending test pieces shall withstand being bent, without fracture, until the sides are parallel at a distance apart of not more than three times the thickness of the specimen.

In ascertaining the strength of the shells of cylindrical boilers, the actual minimum tensile strength of the plates, as found by the tests, may, as heretofore, be used in making the calculations to determine the working pressure.

Angle, Rivet and Stay Bars.—At least two tensile tests shall be taken from each charge of steel; but when the number of bars, as rolled, from one charge exceeds 15, an additional test shall be made from each further 15 bars or portion thereof. In round bars 1¾ inches in diameter and under, the number given above shall, in each case, be 50 in place of 15.

A cold or a temper bend test shall be made from each angle or tee bar rolled, and a cold and a temper bend from every 15 stay bars, as rolled from each charge. No bending tests need be made from rivet bars.

The tensile strength of longitudinal stays, angles and tee bars shall be between 27 and 32 tons per square inch with an elongation of not less than 20 percent measured on the appropriate standard test piece. For bars for combustion chamber stays, the tensile strength shall be between 26 and 32 tons per square inch, with an elongation of not less than 23 percent measured on the standard test piece. But when stay bars are tested on a gage length of four times the diameter, the elongations shall be 24 percent and 28 percent, respectively.

For tee or angle bars under .375 inch in thickness the elongation may be 3 percent below that specified for plates.

Bending test pieces of bars shall withstand being bent, without fracture, until the sides are parallel at a distance apart of not more than three times the thickness or diameter of the specimen.

The tensile strength of rivet bars shall be between 26 and 30 tons per square inch, with an elongation of not less than

25 percent, measured on a test piece whose gage length is not less than eight times its diameter, or 30 percent if measured on a test piece whose gage length is not less than four times its diameter.

Rivets.—A few rivets of each size shall be selected by the surveyor from the bulk and shall be subjected to the following tests:

(*a*) The rivet shanks to be bent cold and hammered until the two parts of the shank touch, without fracture on the outside of the bend.

(*b*) The rivet heads to be flattened, while hot, until their diameter is two and a half times the diameter of the shank, without cracking at the edges.

A few check tensile tests of rivets shall also be made when the surveyor considers it necessary; and in the case of boilers for which special certificates are required, a few tensile tests of the rivets of each size shall always, as heretofore, be made in addition to the above. The elongation shall, when practicable, be taken in a length of two and a half times the diameter of the prepared part; the tensile strength should be from 27 to 32 tons per square inch and the contraction of area about 60 percent.

STEEL FORGINGS.

The forgings shall be made from sound ingots, and not more than the lower two-thirds of the ingot may be utilized for forging. The sectional area of the body of the forging may not exceed one-fifth of the sectional area of the original ingot; and no part of the forging shall have more than two-thirds of the sectional area of the ingot. All ingot steel forgings shall, after completion, be thoroughly annealed at a uniform temperature; and, if any subsequent heating is done, the forging shall, if required by the surveyor, be again annealed.

At least one tensile and one bend test shall be taken from each forging; but if the weight exceeds 3 tons a tensile and a bending test shall be taken from each end. The test pieces shall be cut from a part of the forging of sectional dimensions not less than those of the body of the forging, and shall be machined to size without further forging down. They shall not be cut off until the annealing has been completed and they have, subsequent thereto, been stamped by the surveyor.

The tensile strength of steel forgings shall not exceed 40 tons per square inch; and the elongation shall not be less than 17 percent for 40-ton steel; and in no case may the sum of the tensile strength and the corresponding elongation be less than 57.

The bending test pieces must withstand being bent through an angle of 180 degrees, without fracture; the internal radius of the bend being not greater than that specified below:

Maximum Specified Tensile Strength of Forging.	Internal Radius of Test Piece After Bending. Inch.
Up to 32 tons per square inch................	1/4
Above 32 tons and up to 36 tons per square inch.	3/8
Above 36 tons and up to 40 tons per square inch.	5/8

STEEL CASTINGS.

All steel castings shall be thoroughly annealed at a uniform temperature and shall be allowed to cool down prior to removal from the annealing furnace; and if subsequently heated, with the surveyor's approval, shall again be similarly annealed if required by the surveyor. Test pieces shall not be cut off till stamped by the surveyor, which shall not be done until the castings have been annealed.

No tests need be made from unimportant steel castings or from steel castings which are used for articles usually made of cast iron, if the scantlings are not materially reduced below what would be required if cast iron were used. All other steel castings shall be tested as follows:

At least one tensile and one bending test shall be made from the castings from each charge; and where a casting is made from more than one charge, at least four tensile and four bending tests shall be made from pieces cast as far apart as possible on the casting and as near the top and the bottom, respectively, as practicable.

Where more than one casting is made from one charge, at least one tensile and one bending test shall be made from the castings run from one common pouring head; but separate tests shall be made from each casting or set of castings run from each separate pouring head.

The tensile strength may range from 26 to 40 tons per square inch, with an elongation of not less than 15 percent. But if the castings are to be used for the more important pieces of machinery, such as pistons, etc., or for articles usually made of wrought material, the elongation must not be less than 20 percent where the corresponding tensile strength is between 26 and 35 tons per square inch.

The bending test pieces must withstand being bent, without fracture, through an angle of 60 degrees if the tensile strength is between 35 and 40 tons per square inch; and, in the case of other castings, through an angle of 90 degrees. But if they are required to be of the superior quality referred to above the angle must not be less than 120 degrees. The internal radius of the bend in each case may not be greater than 1 inch.

Superheaters.

Early difficulties with superheating tubes in England have been partially overcome by adopting solid drawn steel in place of copper and cast iron. The apparatus is not only safer but its life approximates more nearly the life of the boiler itself. A superheater attached to a boiler may abstract 10 percent of the heat in the flue gases and reduce the efficiency of the boiler by something like the same figure, but as this extra 10 percent of heat in the steam may reduce the engine losses by 20 percent there is a substantial net gain. With independently-fired superheaters the coal consumption is probably not less than with saturated steam. With ordinary fine or integral superheaters the effect on the coal consumption depends upon whether or not an economizer is fitted and the position of the superheater, whether directly over the fire or in the flue, meeting the gases after leaving the boiler proper. Superheaters are most economical when there is no economizer, and in that case should never meet the hot gases before they reach the boiler heating surface.

In designing the formers for any head the shrinkage of the plate has to be taken into consideration. A good rule is to add to the female die .008 of the diameter of the finished head for heads up to 60 inches and .01 of the diameter for larger sizes. For the male die subtract twice the thickness of the plate plus 1/16 inch to 1/4 inch for upset of clearance, according to the thickness of the plate. This should not be considered a hard-and-fast rule, as no set rule can be given for all classes of work. The designer must make his own allowances, taking into consideration the kind of work to be done and the results of his own experience.

From several complex formulas and the observed results of successful practice, a simple rule for chimney design has been deduced which is used by many engineers. It is as follows: The area of the chimney should be one-eighth of the area of the grate, and the height of the stack should be twenty-five times its diameter.

Bracing Boiler Heads with Angle Bars.

When the shell of a horizontal return tubular boiler does not exceed 36 inches in diameter, and is designed for a maximum working pressure of 100 pounds per square inch, the segment of the head above the tubes may be stayed by steel angle bars. The formula used to compute the size of these bars is as follows:

$M = \frac{f\,I}{y}$; where f = the allowable fibre stress of the material; I = the moment of inertia of a cross section of the bar about a horizontal axis through its center of gravity; y = the distance of the most-strained fibre in the bar from the neutral axis; M = the maximum bending moment in the bar.

Of these quantities, the first, the allowable fibre stress of the material, f, may be assumed to be 16,000 pounds per square inch. This is about one-half the elastic limit of the material, and is equivalent to using a factor of safety of about 4. I, the moment of inertia, may be found by looking up in a handbook the properties of steel angles. If such a book is not at hand the moment of inertia may be calculated approximately by taking account merely of the horizontal leg of the bar, in which case the cross section will be a rectangle, and the neutral axis will pass through its center. The moment of inertia of a rectangle is equal to $\frac{b\,h^3}{12}$; where b is the thickness of the beam in inches, and h the height of the bar in inches. In this case y, the distance of the most-strained fibre from the neutral axis, would be one-half h. The maximum bending moment of the beam, M, is found by assuming that the angle bar is a beam supported at the ends and loaded uniformly; in which case $M = \frac{W\,L}{8}$; where W is the total weight to be supported in pounds, and L is the length of the bar in inches.

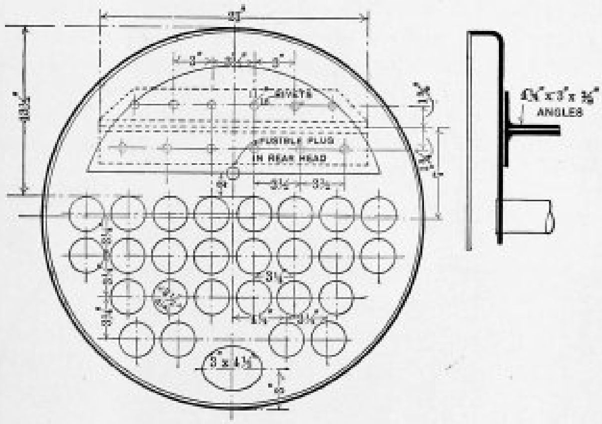


FIG. 1.

Assuming, for example, a horizontal return tubular boiler 30 inches in diameter, as shown in Fig. 1, we may brace the segment of the head above the tubes by two steel angle bars, each 4½ by 3 by ⅜ inches, placed back to back and riveted to the head, as shown in the drawing. In this case the distance from the tubes to the shell is 13½ inches, and the area to be stayed is 143.5 square inches. Therefore, the total load on the head, which must be supported by the angle bars at 100 pounds steam pressure, will be 143.5 × 100, or 14,350 pounds. The length of the bar is 21 inches, and, therefore, the bending moment in the bar is $\frac{14{,}350 \times 21}{8}$, or 37,670 pounds.

This is the bending moment set up in the bar by a steam pressure of 100 pounds per square inch. We must now figure up the strength of the bars to see if they are capable of sustaining this bending moment. First it is necessary to find the moment of inertia. This, according to the formula, $\frac{b\,h^3}{12}$, equals $1/12 \times (4.5)^3 \times ⅜$, or 2.85. $y = \frac{4.5}{2} = 2.25$. Therefore, the bending moment which one angle is capable of resisting will be $\frac{f\,I}{y} = \frac{16{,}000 \times 2.85}{2.25} = 20{,}266$ pounds. Therefore, the resistance of one angle is 20,266 pounds, and of two angles 40,532 pounds, which is more than the bending moment set up in the bar by a steam pressure of 100 pounds per square inch.

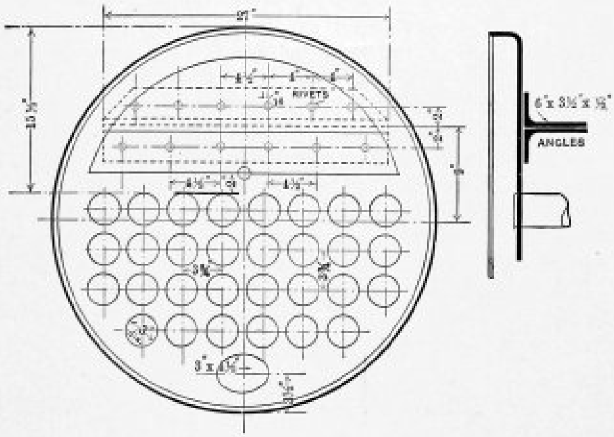


FIG. 2.

In the foregoing calculation we used an approximate value for the moment of inertia of the bar, found by disregarding the vertical leg of the angle, and figuring only on the horizontal leg. Taking account of the whole angle, the moment of inertia in this case is 5.5, and the distance of the most-strained fibre from the neutral axis, or the value for y, is 3.01 inches. Therefore, the resistance of one angle, or the value for $\frac{f\,I}{y}$, really equals $\frac{16{,}000 \times 5.5}{3.01}$, or 29,250 pounds, and the resistance of both angles is 58,500 pounds. Therefore, it is evident that the first calculation, in which only approximate values were used, was on the safe side, because the values found were smaller than those which actually exist.

In the case of the 36-inch boiler, shown in Fig. 2, two 6 by 3½ by ½-inch steel angles are used. The distance from the tubes to the shell in this case is 15½ inches, and consequently the area to be stayed is 220½ square inches. The load on this at 100 pounds pressure is 22,050 pounds. The length of the bar is 27 inches, and, therefore, the bending moment due to 100 pounds steam pressure is $\frac{W\,L}{8} = \frac{22{,}050 \times 27}{8} = 74{,}420$.

The moment of inertia, figuring only on the horizontal leg of the angle is $1/12 \times (6)^3 \times ½ = 9$; $y = 6 \div 2$, or 3. Therefore, the resistance of one angle to bending is $\frac{f\,I}{y} = \frac{16{,}000 \times 9}{3} =$

48,000 pounds, and the resistance for both angles is 96,000 pounds.

The true value for the moment of inertia in this case is 16.59, and the value for y is 3.92 inches. Therefore, the true value for the bending moment $\frac{fI}{y}$ is $\frac{16,000 \times 16.59}{3.92} = 68,000$ pounds, and the resistance of both angles is 136,000 pounds.

A Reinforcing Flue Sheet.

A reinforcing flue sheet for a locomotive boiler has recently been designed and placed in service with good results by Mr. J. A. Doarnberger, master boiler maker, Norfolk & Western Railway, at Roanoke, Va. The device consists essentially of a second flue sheet placed about 8 inches in front of the back flue sheet, of somewhat thicker material than the latter, and thoroughly fastened to it with stay-bolts. The flues extend from the front tube sheet to the reinforcing sheet, being simply expanded at both ends without beading. A short section, or detachable safe end, one end of which is swaged down to fit inside the main part of the flue, connects the reinforcing sheet with the back flue sheet.

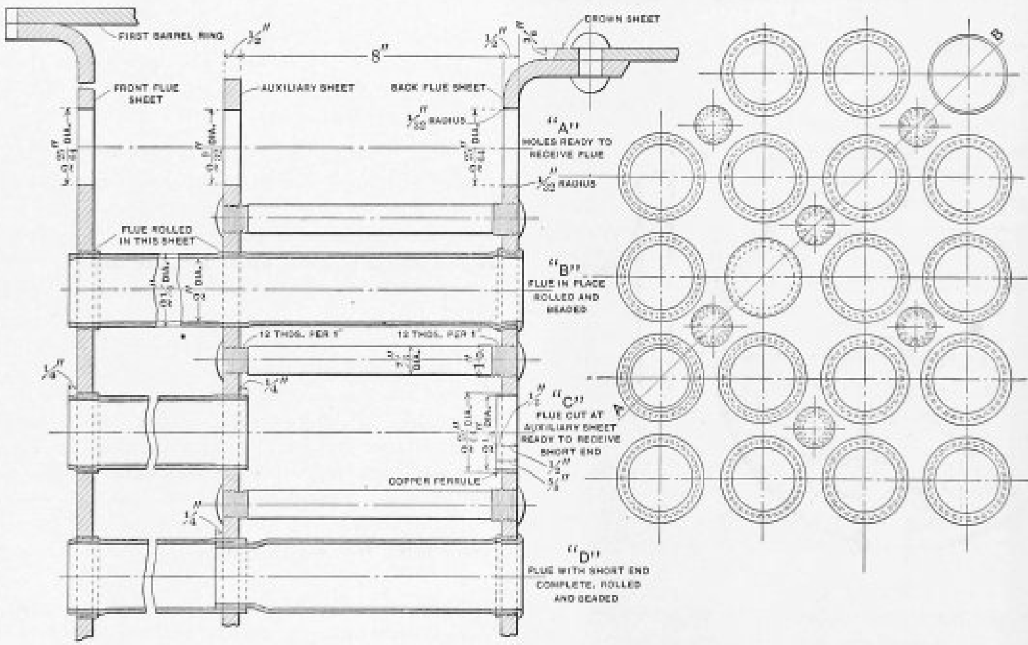
This construction accomplishes several desirable results. In the first place, the reinforcing sheet forms a strong support for the back flue sheet, so that it is practically impossible for it to bulge. It provides a detachable safe end for the flues, so that when a flue wears out at the back flue sheet, as it commonly does, it is not necessary to remove the entire flue and reweld a new safe end onto it, but the short detachable safe end can simply be cut out and another substituted in a very short time. Furthermore, there is by no means as much strain on the flues, due to expansion and contraction, tending to cause leakage at the fire-box end. In fact, it is simply necessary to roll the flues at the back flue sheet without beading them over, as they simply have to withstand the collapsing pressure due to the steam pressure in the boiler, and not any longitudinal stresses due to the expansion or contraction of the tube. For this reason the flues can be used even after the beads, or the ends which are allowed to project an eighth of an inch or so through the flue sheet in case the flues are not beaded, are entirely burned away before it is necessary to replace the safe end.

Another advantage claimed for the reinforcing sheet is that it provides a means for better circulation of the water around the back flue sheet, since it forms a narrow channel through which the water will tend to flow.

The outline of the reinforcing sheet is shown by the dotted lines in Fig. 3. It is evident that considerable care and skill must be used in drilling the tube holes in this sheet, so that they will correspond exactly with the holes in the back flue sheet; and in order to accomplish this, the reinforcing sheet is usually bolted to the back flue sheet and the holes drilled coincidentally.

The flues in all the locomotives which have so far been equipped with this reinforcing sheet have been spaced in vertical rows. In the case of the boiler shown in the illustrations there are two hundred and fifty-eight 2¼-inch flues, spaced 3⅛ inches between centers. Since these are placed in vertical rows the bridges are ¾ inch wide. In the center of every rectangle, formed by four adjacent flues, a stay-bolt is placed. These bolts, therefore, are also in vertical rows, 3⅛ inches apart, and their position does not decrease the width of the bridges. These stay-bolts are ⅞-inch diameter at the center, and are threaded at either end and riveted over both flue sheets.

In the earlier applications of the reinforcing sheet ordinary flues were used, extending from the front tube sheet to the back tube sheet, and these were expanded into the reinforcing sheet. This provided ample support for the back flue sheet, as was intended; but, of course, the expense of the flue work was in no way decreased. The idea was then conceived of cutting off the main flue at the reinforcing sheet and using a short section swaged down at one end to form a telescopic joint at the reinforcing sheet, forming a detachable safe end. In the latest design of this construction Mr. Doarnberger has used a heavier auxiliary sheet and has butted the flues and the safe end. Expanding a flue which extends only part way into the flue sheet in this way seems to give a joint with sufficient strength, as in one case the end of the flue which was ex-



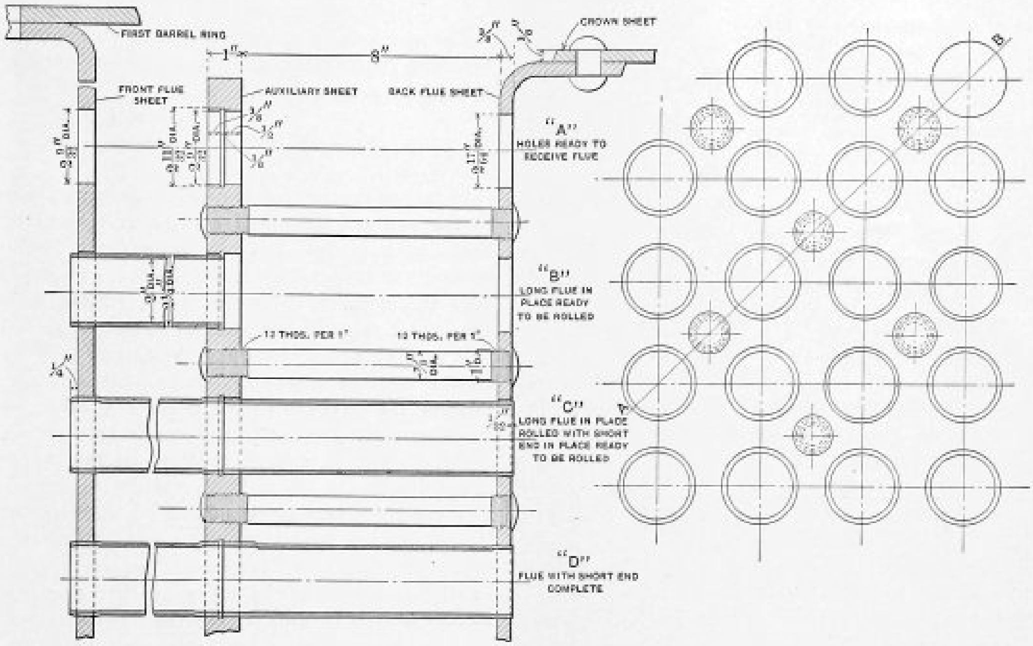
SECTION ON A-B

FIG. 1.—REINFORCING SHEET WITH TELESCOPIC JOINT BETWEEN FLUE AND DETACHABLE SAFE END.

panded in the usual manner in the front flue sheet pulled out with a load of 8,755 pounds, while the end which was expanded half-way into the auxiliary sheet pulled at a load of 15,665 pounds.

So far all of the engines have been equipped with this device as they were handled through the shop, none of them having been designed for it originally. No trouble has been be seen that this device, which does away with the necessity of shopping the engine for flue work, will have a very great effect upon the usefulness of the engine.

We are indebted to Mr. W. H. Lewis, superintendent of motive power, and Mr. J. A. Doarnberger, master boiler maker of the Norfolk & Western Railway, Roanoke, Va., for the illustrations and data used in this article.



SECTION ON A-B

FIG. 3.—REINFORCING SHEET WITH BUTT JOINT BETWEEN FLUE AND DETACHABLE SAFE END.

found with leakage of joints at the reinforcing sheet, and the bead on the detached end gives the same amount of service as on an ordinary flue. The principal gain is found in the saving of time and labor in the renewal of safe ends, where

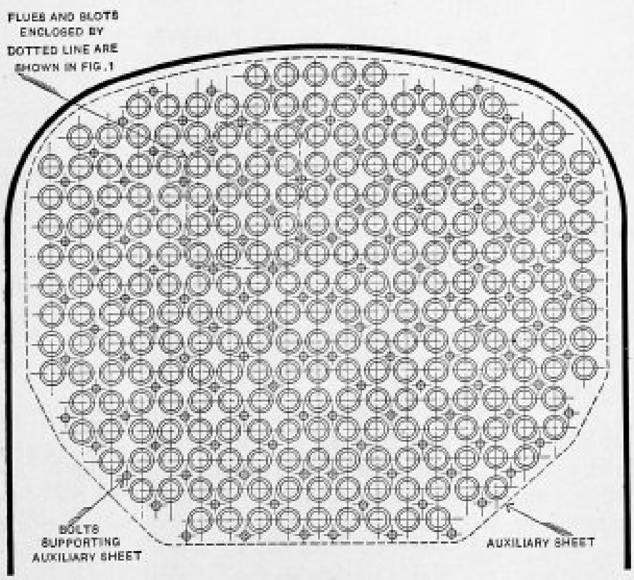


FIG. 3.—OUTLINE OF AUXILIARY SHEET.

the beads have worn off or burned away, since this can be done in the round-house without taking the engine to the shop and removing an entire set of flues, with the consequent disarrangement of the steam pipes, deflecting plates, etc., in the front end. In some places the flues very largely determine the mileage of a locomotive between shoppings, and it will

How to Repair a Leaky Tube While Under Steam.

First fit an iron rod as long as the tube with a thread on each end. Then, starting at the left-hand end of the rod Fig. 1, screw on a nut; then put on a washer just a little smaller than the tube; then a plug of rubber; then another washer; now put on a piece of piping of such length that after similar

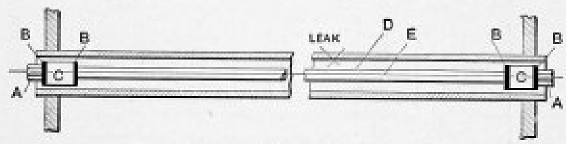


FIG. 1.

fittings are placed on the other end the whole thing will be about the length of tube. The other end is then fitted like the first, and the piece of apparatus can then be pushed into the tube from the front, and as you set up on the nuts the rubber will be so pressed outward as to stop up the tube.

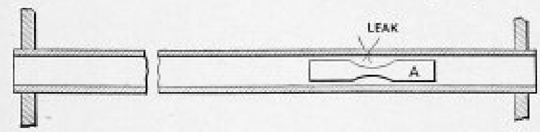


FIG. 2.

The above form of tube stopper is good, but cannot be relied upon, as the fire burns the rubber after being in a short time, and leaking is likely to set in, especially when under heavy pressure, but in a case of emergency it may be very useful. Another method is shown in Fig. 2. A soft pine plug shaped as in the figure may be pushed into the tube until it covers the location of the leak. Steam and water from the leak will then cause the ends to swell and stop the leak.

Table of Efficiencies of Double-Riveted Lap Joints for Boilers where Steel Rivets are Used.

One of the casualty companies has recently published a table which is of interest to boiler makers, showing the efficiencies of double-riveted lap joints for boilers where steel rivets are used in which the tensile strength of the plate is taken at 55,000 pounds per square inch of net section, and the shearing strength of the steel rivets, at 42,000 pounds per square inch of net section in single shear.

The Massachusetts law allows 42,000 pounds for steel rivets and it is probable that this ruling will become general although the Philadelphia ordinances allow 45,000 pounds. The engineering profession will recognize the value of the table at a glance; but for the benefit of boiler owners and others interested (at least to some extent) in steam, we offer the following explanation:

T. S. = Tensile Strength.
T = Thickness of Shell Plate.
R = Radius or ½ the diameter.
E = The efficiency of the longitudinal seams as compared with solid plate.
F = Factor of safety.
W. P. = Working pressure.

The safe working pressure of a steam boiler as respects the shell or cylinder, as in a horizontal tubular type, is calculated *then* as follows:

$$W.\ P. = \frac{T.\ S. \times T \times E}{R \times F}$$

In this calculation, *F* is usually taken at 4½ to 5, according to the age and general condition and as to whether or not State or municipal rules may govern. The importance of finding the true value of *E* cannot be overestimated—otherwise the computation would be worthless, for *E* represents the lowest value of the joint as compared with the solid plate.

It will be noted that the rule applies only to the strength of the shell of a boiler. The calculations necessary to determine the strength of the heads and other parts of boilers of other types are not considered in this article.

We do not, of course, recommend the lap joint on seams parallel with the axis of the cylinder or shell; but inasmuch as there are a very large number of boilers in use constructed in this manner with steel rivets and lap joints, this table will prove of value to all inspectors, engineers and boiler men in readily determining the value of such double-riveted joints, having pitches ranging by eighths from 2 inches to 3½ inches.

In practice the steel rivet has superseded the iron one owing to its higher shearing strength and to its being easier to handle on new work, as well as on repair jobs. Modern methods of driving rivets leave little doubt as to the rivets filling the holes. Furthermore, by means of pneumatic reamers rivet holes may be made perfectly true without the use of the drift pin, which, by the way, is a tool that is no doubt responsible for many explosions.

TABLE OF EFFICIENCIES IN PERCENT FOR DOUBLE-RIVETED LAP JOINTS.

T. S. of Plate, 55,000 □" and *S. S.* of Steel Rivets, 42,000 □".

Pitch.	Hole.	Thickness of Plate.				
		1/2	7/16	3/8	5/16	1/4
2"	1	50.0	50.0	50.0	50.0	50.0
	15/16	53.1	53.1	53.1	53.1	53.1
	7/8	56.3	56.3	56.3	56.3	56.3
	13/16	59.3	59.3	59.3	59.3	59.3
	3/4	62.5	62.5	62.5	62.5	62.5
	11/16	56.8	65.0	65.8	65.8	65.8
2⅛"	1	53.0	53.0	53.0	53.0	53.0
	15/16	56.0	56.0	56.0	56.0	56.0
	7/8	59.0	59.0	59.0	59.0	59.0
	13/16	61.8	61.8	61.8	61.8	61.8
	3/4	63.8	64.9	64.9	64.9	64.9
	11/16	53.6	61.1	67.8	67.8	67.8
2¼"	1	55.6	55.6	55.6	55.6	55.6
	15/16	58.3	58.3	58.3	58.3	58.3
	7/8	61.2	61.2	61.2	61.2	61.2
	13/16	63.9	63.9	63.9	63.9	63.9
	3/4	60.1	66.8	66.8	66.8	66.8
	11/16	50.3	57.8	67.2	69.6	69.6
2½"	1	60.0	60.0	60.0	60.0	60.0
	15/16	62.5	62.5	62.5	62.5	62.5
	7/8	65.0	65.0	65.0	65.0	65.0
	13/16	63.5	67.4	67.4	67.4	67.4
	3/4	54.0	61.9	70.0	70.0	70.0
	11/16	45.5	52.0	60.7	72.5	72.5
2⅝"	1	61.9	61.9	61.9	61.9	61.9
	15/16	64.3	64.3	64.3	64.4	64.3
	7/8	66.8	66.8	66.8	66.8	66.8
	13/16	60.5	69.1	69.1	69.1	69.1
	3/4	51.5	59.0	68.8	71.5	71.5
	11/16	43.2	49.5	57.8	69.2	73.9
2¾"	1	65.2	65.2	65.2	65.2	65.2
	15/16	67.4	67.4	67.4	67.4	67.4
	7/8	63.9	69.4	69.4	69.4	69.4
	13/16	55.1	63.0	71.9	71.9	71.9
	3/4	47.0	53.8	63.0	74.0	74.0
	11/16	39.5	45.2	52.9	63.9	76.1
3"	1	66.6	66.6	66.6	66.6	66.6
	15/16	68.9	68.8	68.9	68.9	68.9
	7/8	61.2	70.2	71.0	71.0	71.0
	13/16	52.8	60.5	70.4	73.0	73.0
	3/4	45.0	51.6	60.0	72.2	75.0
	11/16	37.9	43.3	50.5	60.8	75.8
3¼"	1	69.1	69.1	69.1	69.1	69.1
	15/16	65.0	71.1	71.1	71.1	71.1
	7/8	56.6	64.7	73.1	73.1	73.1
	13/16	48.8	55.7	65.1	75.0	75.0
	3/4	41.7	47.5	55.6	66.5	77.0
	11/16	35.0	39.9	46.7	55.9	70.0
3⅜"	1	70.3	70.3	70.3	70.3	70.3
	15/16	62.6	71.6	72.2	72.2	72.2
	7/8	54.6	62.3	72.8	74.1	74.1
	13/16	47.0	53.8	62.8	75.2	76.1
	3/4	40.2	45.8	53.5	64.2	77.8
	11/16	33.7	38.5	45.0	53.8	67.2
3½"	1	68.6	71.5	71.5	71.5	71.5
	15/16	60.2	69.0	73.3	73.3	73.3
	7/8	52.6	60.2	70.1	75.0	75.0
	13/16	45.2	51.8	60.6	72.6	76.9
	3/4	38.5	44.2	51.6	61.9	77.4
	11/16	32.5	37.1	43.2	52.0	65.0

Rivet Heating in Oil Furnaces.

The rivets used in the shops of the Penn Bridge Company, at Beaver Falls, Pa., are heated in both stationary and portable furnaces using oil. This fuel is stored in a 10,000-gallon tank buried in the ground near a railway siding, so that it can be readily filled from cars. The oil is delivered under 20-pound pressure from the tank to the burners by Kirkwood apparatus, which also strains it and raises its temperature to the proper point for complete combustion. The compressed air for atomizing the oil is taken from the regular air mains of the shops and sent through a regulating valve, which reduces its pressure to 15 pounds for use in the burners. It is stated that 50 cubic feet of air at that pressure is enough for burning a gallon of oil.

There are in the shops five double-door stationary 16 by 24-inch rivet forges, four 12 x 16-inch single-door forges, and a 12 by 18-inch portable forge mounted on a tank containing the oil and connected by a flexible hose with the compressed air main. Each furnace has a burner with a single operating lever controlling both the air and oil, as it is considered best to operate them with one proportion of mixture only, which is fixed at the maker's factory.—*Engineering Record.*

The weight of steam in pounds delivered per second by a safety valve is equal to the effective area of discharge in square inches times the absolute steam pressure in pounds per square inch divided by 70.

Some Causes of Boiler Failure.

Although boilers differ materially in design and construction in different countries, yet the causes for boiler failures and explosions are practically the same the world over. We have frequently published detailed accounts of the more serious boiler explosions which have occurred in this country and others where it was possible to determine the cause of the explosion and present clearly the conditions which led up to the failure. We have also frequently published carefully written and comprehensive articles on some of the individual causes of boiler explosions, showing wherein the danger lies and how it may be obviated.

In line with this same general subject Mr. George Ness, in a paper which he recently read before the West of Scotland Iron and Steel Institute, states that the principal causes of failure in modern boilers are corrosion, mechanical action due to expansion and contraction, seam rip and overheating—the result of shortness of water or excessive deposit.

Corrosion internally is generally the result of acidity of the feed water, and external corrosion the result of dampness in the seating, leakage from seams, or corrosive acids in the products of combustion. Acidity in feed water and other impurities can, as a rule, be obviated by chemical treatment, water softening and filtration; many successful installations of this order being in operation all over the country.

Overheating, due to deposit of lime, salts, or other solid matter on the heating surfaces, can be entirely eliminated by the same means; but shortness of water, over pressure and stoking still remain as probable causes of undue wear and accident, and although automatic appliances for dealing with these have been introduced, they do not, by any means, render the services of capable attendants less necessary.

MECHANICAL ACTION.

Mechanical action, which is present in all boilers, due to the movements of expansion and contraction arising from the varying temperatures of the different plates, and also to the stresses brought upon them by the internal pressure, is frequently aggravated by chemical action.

In many boilers of the lap-jointed type, the shell or furnaces are out of the true cylindrical form, at least to the extent of the plate thicknesses. Owing to the continual variation of the pressure at one moment tending to force the shell towards, and the furnace further from, the cylindrical shape, and at the next instant the strain of the plate, when the stress is removed, tending to bring it into the original form, bending stresses are set up on the plate at the edges of the double thicknesses, by which action local detrition of the material takes place, known technically as "grooving." This action is analogous to the repeated bending of hoop iron, which breaks away surface particles, and finally results in local fracturing. This grooving, if severe, may be expected in time to completely penetrate the plate, though in some cases it has been found, after having attained a certain depth, to become inactive, as if by the reduction of the material a certain elasticity had been attained, which protected the parts affected against further wasting.

Where the ends of the boilers have too little breathing space, or the furnaces have not the necessary elasticity at the joints of the plates, grooving is set up immediately over the furnace attachments, or on the flanged or angle ring connections of the furnace tubes. Where there is no chemical action in the feed water these groovings may take the form of a thread or fine fracture, very difficult to locate, even to the expert whose experience teaches him what to expect, and this difficulty is considerably increased when the preparation for examination has been of a perfunctory nature and the defects are covered with scale or deposit. When chemical action is present, the local detrition becomes more pronounced and extended, and is easily detected.

GROOVING IN LOCOMOTIVE-TYPE BOILERS.

In locomotive-type boilers, grooving is found at the vertical flanged corners of the face plate and saddle plate, on the casing plates along the line of the foundation ring, on the plates around the necks of the stays, and at necks of the stays themselves. Again, when no chemical action is present, the stays may fracture through as if cut with a knife, but generally there is a sufficient evidence of the wasting, if the construction will permit of close inspection. In regard to the stays, those most seriously affected are generally the two or three top rows, the intensity of the stresses increasing towards the upper rows, due to the panting action of the fire-box under the influence of varying temperatures. In addition, there is the grooving along the edges of the seams of the barrel, if designed in the method already alluded to. In vertical boilers grooving is principally found around the up-take tube connection to fire-box crown, and at the bottom of the fire-box where connected to shell, as a result of the upsetting action at these parts.

With this necessarily short notice of the various forms of wear and tear, and failure in steam boilers, attention is now drawn to boilers of Cornish and Lancashire type, both of which, but particularly the latter, are to be found in operation at every well-equipped colliery and factory in this country.

CORNISH AND LANCASHIRE BOILERS.

The single-flued internally-fired boiler, commonly known as the Cornish boiler, because of its first general adaptation in Cornwall, was of a more economical type, and as, owing to its construction, it was less liable to damage from the extremes of temperature, due to hand firing, than the plain cylindrical, it was received with favor.

Cornish boilers, although in many respects well adapted for the requirements of the smaller manufacturer, are rapidly disappearing. The tendency of modern times towards combinations of manufacturers, along with the introduction of electric power supply companies, has brought about a great reduction in the number of small boilers of all types, and the Cornish boiler, along with those of vertical type, are now very little in evidence, although within recent years there have been installed in sawmills of small power a number of Cornish boilers, 6 feet 6 inches diameter, designed for a working pressure of 120 pounds per square inch, the furnaces being 3 feet 3 inches diameter. These have proved to be very serviceable, the large furnaces being well adapted for the combustion of sawdust and timber refuse.

The Lancashire boiler is too well known to require any lengthened reference, but I may point out that owing to the demands for higher steam pressures, its proportions and dimensions have been greatly increased, and boilers of this type are now being made up to 9 feet 6 inches diameter, for pressures up to 200 pounds per square inch (weighing about 40 tons), so that we have pretty nearly arrived at the practical limits of size and pressure.

The great bulk and weight of such boilers present difficulties in handling and transit which render them liable to damage from shock. Increased rigidity, due to the necessity for using heavier plating, riveting and staying, and the more severe temperature stresses to which the thick shell plate heating surfaces are subjected, suggest a greater liability to grooving and fracture than that experienced in Lancashire boilers of smaller dimensions and proportionately lighter scantlings.

The displacement of plain cylindrical boilers in iron works and at collieries in favor of those of Lancashire type was a very gradual process, and for a considerable period after their introduction there was no material increase of the steam pressures carried in the older types, which usually averaged some 40 pounds or so per square inch. There were doubtless good reasons for this: the proportions of the engines in use would not permit of higher pressures being employed, and as in many instances the Lancashire boilers had to work in connection with those of plain cylindrical type, a complete reconstruction of the power plant had to be faced if higher steam pressures were to be adopted.

The Lancashire boiler was an extremely economical steam producer. and is still a favorite throughout the country. It has large steam disengaging surfaces, and as it contains a large volume of water and, therefore, a great storage of heat, it is peculiarly adapted for such circumstances where a large and sudden demand for steam is made. The construction of boilers also received considerable attention from the makers. The introduction of steel and the undoubted confidence which experience has given of the behavior of that material have all tended to bring boiler manufacture as carried out by first-class makers to an acme of perfection. Special tools for the purpose of bending, drilling, riveting, flanging, enable the work to be carried out with almost mathematical accuracy, and proportions of the various scantlings are now designed on really scientific lines. As pressures increased and difficulties of handling the transit had to be provided for with increased sizes, water-tube boilers gradually came into use.

There are now a fairly large number of firms engaged in the manufacture of water-tube boilers of different designs, but for land purposes, Messrs. Babcock & Wilcox. until quite recent years, had no competition of any importance. These boilers are very suitable for high pressure, and large power can be installed in small compass, compared with those of Lancashire type. They are also well adapted for transit, and generally they meet the exacting demands of the day in a very satisfactory manner. Amongst other well-known types are the Stirling boiler and the Nesdrum boiler.

RECENT DECISIONS UNDER THE "BOILER EXPLOSIONS ACT."

A brief reference may here be made to decisions arrived at by the commissioners appointed under the "Boiler Explosions Act," in recent inquiries into the cause of boiler explosions, and the result as affecting steam users generally.

In the case of one boiler explosion which occurred in the Midlands, the scale deposit was stated by the inspector to be 1/16 inch thick, and his conduct in signing a certificate that the boiler was properly prepared was strongly animadverted upon by the legal commissioner. The insurance company and owners were censured and fined for not removing some brickwork which covered one of the seams, at which part the Board of Trade surveyors stated that the rupture was initiated. This view was accepted by the commissioners, although the bursting pressure at the part named was at least three times the working pressure, which working pressure it was admitted, was not exceeded. The boiler, according to other expert evidence, ruptured through a circular seam, due to seam rip extending for about two-thirds of the circumference, doubtless caused by the severe straining to which the boiler was subjected, fired as it was from two puddling furnaces. This theory was entirely set aside in favor of that of the Board of Trade surveyors, one of whom admitted he had never examined an egg-end boiler previously, and the other of whom admitted he had never heard of seam rip.

In another recent case, the Boiler Insurance Company and chief engineer were heavily fined because they had not recommended the removal of the boiler brickwork, the commissioners laying down their view that the removal of brickwork at frequent intervals was a matter of necessity, and that the policy of insurance companies in considering the question of expense to steam users was an untenable one.

Quite recently again, at Coatbridge, one of the questions put by the Board of Trade solicitor to an expert, who appeared for the firm owning the boiler which had failed, was: "Are we to understand that in your view there was no method known to engineering science which could have been applied to ascertain whether such a defect existed?" The reply pointed out that no method of inspection or testing equals visual inspection, and that the case came under the classification of *damnum fatale*. This view was not actually accepted by the commissioners, but their censure was mild and likewise the fine.

All the recent decisions lead up to this, that the old idea of "a boiler whose scantlings are suitable for a certain pressure, and in which no material defects are observed, may be certified as fit for that purpose," must yield to the new order in which safety is the ultimate goal, and "no boiler may be certified unless every precaution has been taken and every method known to engineering science has been applied to ascertain that no defect materially affecting the safety of the boiler exists at any part." This places a great responsibility, not only upon inspection companies, but also upon steam users.

THE PERIODICAL STRIPPING OF THE BRICKWORK.

As a result of complaints received from factory inspectors, the Home Office have just issued a new Form 55 to comply with Section 11 of the Factories and Workshop Act, and this will come into force as soon as certain details have been satisfactorily settled by the Home Office.

From the whole trend of recent legislation and of published reports, it is therefore evident that steam users generally must face the more frequent periodical stripping of brickwork and covering from boilers, and the thorough removal of deposit from the water-side. In respect of the periodical stripping of brickwork, the frequency must naturally depend on the conditions appertaining to each particular case, such as situation, maintenance, site, drainage, etc. Generally, however, it may be taken that boilers which are covered with brickwork or non-porous covering, and well housed so that weather conditions do not affect them, should be stripped every ten or twelve years. When covered with porous composition, however, it is sufficient to have the covering removed once in fifteen years.

In the case of boilers which are covered with brickwork or non-porous covering, and exposed to the weather, these coverings should be removed at intervals of five to seven years, but when covered with porous composition they should be stripped every ten years or thereabouts.

The flue covering at the side seating walls, where of ordinary thickness, should be ploughed or opened up opposite the seams every ten years. If the seating walls exceed 4½ inches in width, and the flue coverings 9 inches where in contact with the plates, or are affected by dampness, this should, of course, be done oftener. The gaps in the seatings and flue coverings should be made about 1 foot wide.

Front cross walls should be opened up every ten years. but if more than 9 inches wide, or if not clear of the seams at the front end, they should be removed every second or third year, and in event of their being damp they should be opened up around the blow-off every year.

With regard to vertical boilers and locomotive-type boilers, the composition of lagging with which they are covered should be removed every five or eight years; and these also should be bared if leakage appears.

In particular, however, when leakage or dampness shows itself through the brickwork or composition covering, the brickwork or covering should be removed at once, and the defect made good.

Assuming the useful lifetime of a boiler to be thirty years, boilers which are exposed to the weather and covered with brickwork should have the covering removed about four or five times throughout their useful life; when housed over and not exposed, about twice in their useful life. Boilers covered over with porous non-conductive covering and exposed to the weather, should be opened up about twice in their lifetime, and where protected by buildings from exposure when they have seen about half their service.

Conditions will modify the term of years between "strip-plugs," such as leakage at the seams or joints overhead, etc.

WELDING.

Before leaving the subject of boilers, the author would refer briefly to welding of those parts which are in tension in boilers and other vessels under pressure.

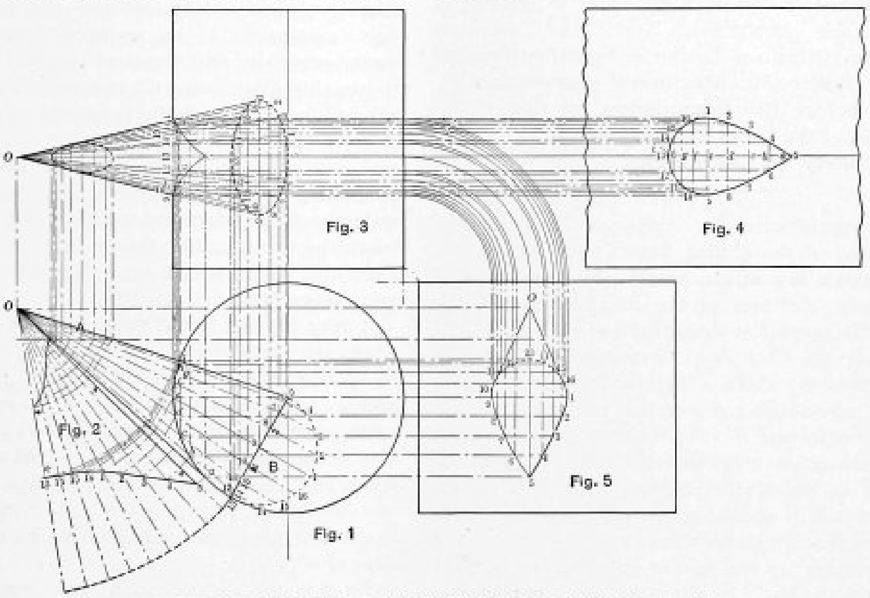
In the case of vertical boilers these are sometimes placed on the market with all the seams welded; in other cases the shell seams and the up-take connections only are riveted, the seams of shell to shell-crown plate and to fire-box at bottom being welded. This method of construction will probably save from £2 ($9.73) to £5 ($24.33) in price; but, as the joints are most uncertain, it would be well to avoid accepting boilers so constructed, as it will probably involve higher maintenance charges, and necessitate the expenses of preparing the boiler for the application of the hydraulic test at each annual examination.

The writer had recently to investigate the failure of an air receiver which had been installed along with an air compression set in a large colliery, and found that the vessel, which was built of steel, had been constructed with all the seams electrically welded. The vessel was 3 feet in diameter by 10 feet in height. The shell was in two belts of plate ¼ inch thick, having the longitudinal seams welded, and the two rings connected at the mid-circular seam by an outside butt strap, welded inside and outside. The end plates were ¼ inch thick, and were welded to the shell. Both ends were cambered. The back end had the concave surface to the interior, and the front end had the convex surface to the interior.

The compressing set was intended for a working pressure of 100 pounds per square inch. The motor was started up, but when a pressure of 110 pounds was reached on the gage it was observed that the safety valve on the compressor was not blowing. The engineer, who held a very important position, and was superintending the starting up of the plant, immediately commenced to slacken back the spring loading the safety valve, when the front end blew out, and the reaction, due to the sudden expansion of released air, drove the receiver upon him, and crushed him to death between the receiver and the compressor.

I carefully examined the welding, and found that at two parts it was barely united, and elsewhere it varied from 1/10 inch to ¼ inch in depth. The welding had a short crystalline character, and had evidently not been annealed after welding. The firm who made it stated they had thousands working which were similarly constructed. My investigations showed the ends to be weak against collapse, whilst the weld proved itself unreliable at about 10 percent above the working pressure. The vessel was stated to have been hydraulically tested to 165 pounds pressure at the works. It would have been interesting to have gaged the behavior of the end under the test, and it is probable that the application of such a high test to a vessel of weak design may have contributed to its final failure by stressing the front end, which was under compression.

This instance alone proves the unreliability of welds under tension, and makes one wonder about the possible fate of the other thousand receivers said to have been similarly constructed.



DEVELOPMENT OF PATTERNS FOR A CONE INTERSECTING A CYLINDER AT ANY ANGLE.

The Layout of a Cone Intersecting a Cylinder at Any Angle.

BY JOHN E. LANDIS.

First draw the end view as at Fig. 1, strike a circle the diameter of the large pipe, then determine the center line of the cone; in this case the cone makes an angle of 30 degrees with the horizontal center line; next draw the semi-circle equal to the diameter of the cone at the base; space this off into any number of equal spaces; in this case 8; now connect these lines with the vertex at *O*. Where these lines meet the circle gives the line of intersection; all these lines are, however, fore-shortened, and the true length must be found by projecting them across until they meet the line *o*-13. The same holds true with the lines that cross the top of the cone *A*. We are now ready to develop the pattern for the cone.

Set one leg of the dividers on the vertex, and with the radius *o*-13 strike an arc representing the base of the cone; now space this arc into the same number of equal parts, as we did the semi-circle, and draw the lines 5-4-3-2-1-16-15-14-13. This gives us only half of the pattern, the other half being just the same. The necessary allowance for laps and take-up, of course, must be added to this.

Next we will develop the opening that will be required. There are several ways to do this, but the following is the most practical method: Draw a section of the cylinder as at Fig. 3. Now draw vertical lines from the points on the base of the cone; also from the points found on the intersections. Take the lengths of the lines 1-1; 2-2; 3-3, etc., on the semicircle *B* and set them off on lines bearing the corresponding numbers in Fig. 3; connect these lines with the vertex, and where they cross the vertical lines gives the exact diameter the cone will be where it is cut at right angles on each line of intersection. Now draw lines from these points over to Fig. 4, the other lengths being found by measuring from *a* to *b*, *b* to *c*, *c* to *d*, etc. This gives us the opening to fit the cone.

Fig. 5 is another view of the cone, looking at the front of it. It is not necessary to make this development, as it was only made to show the method of projections for those that do not understand that part of the problem.

Revision of the United States Marine Laws.

Report of the Committee on Uniform Specifications of the American Boiler Manufacturers' Association Presented before the Commission on the Revision of the Laws Relating to the Safety of Life at Sea.

This committee, representing the American Boiler Manufacturers' Association of the United States and Canada, desire to lay before you a few salient points which our association deems necessary elements in the improvement of the laws and rules relating to the construction of boilers and appurtenances under the Steamboat Inspection Service. In one sense, at least we may claim a historical precedence over other bodies which may address you on this subject.

Our association was formed in 1889, with the avowed object of improving the materials, workmanship and design of all boilers constructed in the United States. Our first efforts were naturally directed to obtaining the passage of uniform boiler inspection laws in the various States of the Union, and developing specifications for the proper materials to be used in the construction of boilers. In the latter work our success was immediate and phenomenal; in the former, after strenuous efforts, extending over a series of years and in various States of the Union, we had to confess complete failure. We finally concluded that a strictly educational campaign offered better chances of success than one looking to the passage of laws, owing mainly to the fact that it would be difficult to bring forty-five or forty-six Legislatures into substantial agreement on the many points involved in a good boiler inspection law. The question of accomplishing the same result for the whole Union, under the Inter-State Commerce clause of the constitution, was duly considered, but dropped as too uncertain.

In considering an educational campaign, it became clear that a standard which would appeal to the city governments of our large municipalities was a prime necessity. The laws and regulations governing the Steamboat Inspection Service presented such a standard, for the rules which govern the construction of boilers on navigable waters will naturally appeal to the Legislatures of municipalities located on such waters. Besides this, a large number of our members building boilers for ocean and lake service and steamboats on the rivers of the country are directly interested in the improvement of the Steamboat Inspection Service. Thus the ideal we had set before us seemed most likely of realization by strengthening and improving the laws and regulations based on the act of 1852. A concise history of our efforts will be found in the *Journal* of the American Society of Naval Engineers, volume 15, and in extracts from the proceedings of our association of 1903, 1904, 1905, 1906 and 1908.

We call attention to these articles in order to show at once the difficulties which stand in the way of a thorough revision of the boiler laws of the Steamboat Inspection Service, the impossibility of meeting the wants of the trades vitally interested in this matter by frequent changes in the regulations or rules under the present system, and the necessity of consulting with the interests naturally involved before any attempted revision is put into the form of a law.

While we confine ourselves strictly to the matter of boilers and their appurtenances, we found it necessary to designate seven such interests, viz.: The Inspection Service, the navy, the Revenue Cutter Service, naval architects and marine engineers, boiler manufacturers, plate manufacturers and ship owners. As your problem covers many other factors concerned in the safety of life on navigable waters, the number of interests which should necessarily be consulted will be materially increased. But we believe that from our experience you will deduce the same conclusion that we did, *i. e.*, that to pass a strong law and one commensurate with the vast development of our mercantile marine, it will be a paramount necessity that the provisions of such a law should be thoroughly discussed with representatives of all the interests affected before it is finally presented as a bill to Congress. And this for the reason that every such law must represent a just and rational compromise between conflicting interests and conflicting knowledge and experience, and that this compromise should be discussed before a board of experts and adjusted by them, rather than take the chances of a debate in Congress, where it is a practical impossibility to have all the facts given their full weight.

It may be well here to suggest that certain technical questions, on which there will, no doubt, exist honest difference of opinion, should be settled by actual tests in full-sized specimens. Such tests could be best made by the navy department, whose engineering staff would approach them without bias and carry them out with the sole object of getting at the truth, and the expense entailed in such tests can best be borne, and should be borne, by the United States Government, for the benefit of the industries on which our national prosperity depends.

To a small extent, such tests have been made by this association, resulting in the disclosure of facts which none of us anticipated. For instance, that riveted seams do not fail by the shearing, but by the stretching of the rivets, and that punched holes resist this tendency more than drilled holes, and that the attempted re-enforcement of spherical heads with longitudinal braces is worse than useless.

We tender for your consideration the results of the tests of seven full-sized shells or drums in the volumes of the proceedings of the American Boiler Manufacturers' Association for 1893 and 1895.

Based on these tests and on the experience of our membership, gained during the discussion of topical questions extending over eight annual conventions, we submit, further, the Uniform American Specifications, adopted by our association and, as showing the necessity for uniform and stringent regulations covering the construction and inspection of steam boilers, a paper by Mr. H. J. Hartley, read in our twentieth convention in July of this year.

We beg to offer for your consideration the following schedule of the elements which should be the basis of any suggested law on the subject of boiler construction:

1. A requirement covering the best materials obtainable in standard American practice, and methods of testing same, with a view to making the qualities thus ascertained the basis

of the permissible stresses, in place of fixing them arbitrarily, as is done by the present rules.

2. Methods of construction should be based on the best modern American practice.

3. The inspection of materials, of design, and of workmanship should be thorough, made by experts, and be final and conclusive, so that a boiler built and inspected at Buffalo should pass muster and be accepted without cavil at San Francisco, New Orleans or Portland. We fully recognize that this raises the qualifications to be demanded of boiler inspectors, and that the service should naturally be placed under the civil service law.

4. In view of the fact that boilers for ocean service will at times come under the inspection of other civilized nations, and must conform to the requirements of the great recognized marine insurance corporations, our inspection laws should be such as to place them at least equal, preferably in advance, of the regulations of European nations.

5. The laws and regulations to be passed under it must meet one important and serious circumstance existing in the United States, namely, the almost diametrically different conditions of marine boilers on the Great Lakes and seaboard, and those of the Mississippi River and its tributaries. To reconcile these on a fair and just basis, duly considering the experience and necessities of our internal water transport, is one of the most difficult problems placed before your honorable commission.

6. The difficulties just referred to can only be met by the suggestions of a complete and careful section, giving proper values to all modern systems of riveted joints in place of the archaic section 4433 of the present law. The last two elements will properly overcome the troubles incident to the change in the prescribed test pieces and in the rules covering the thickness of plate in boilers and flues used in the Mississippi Valley.

7. The law must be general in its provisions and cannot go into much detail, without danger of causing much hardship in the future when conditions change, as they have changed in the past. The system of having regulations framed by the Board of Supervising Inspectors, which, when sanctioned by the Secretary of the Department, have the force of law, is wise, and gives the necessary elasticity which a rigid law cannot, in the nature of the case, provide. But a proviso should be inserted that whenever any change in the regulations is demanded or intended, notice of such demand should be sent to all parties interested who may request to be placed on a mailing list for this purpose; that at least sixty days' notice of the consideration of such change shall thus be given and a time fixed for the discussion of this matter, at which interested parties shall be entitled to take part in the debate of the proposed measure, verbally or in writing, before final action by the board is taken. The office of Supervising Inspector General will necessarily gain in importance, and should be provided with a larger permanent personal staff, to properly make investigations of all technical matters previous to the discussion above indicated, and the Inspector General should have the right to ask for special tests of full-sized specimens on the great government testing machine at Watertown, or, if need be, at any one of the navy yards properly equipped for such tests.

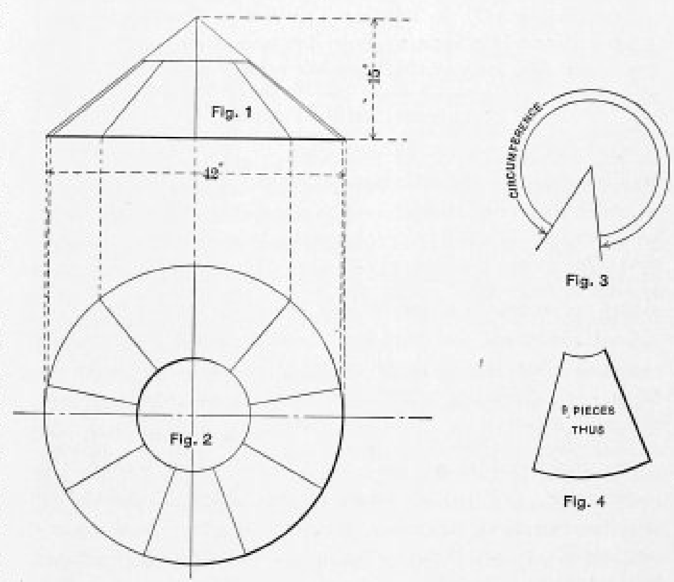
In conclusion we would earnestly recommend that the theory of the bill proposed by our association, and sanctioned by the Board of Supervising Inspectors and by the Secretary of the Department in 1903, be followed in your report, if compatible with your instructions, viz.: that the preliminary draft of a law be prepared and printed and submitted to all societies, associations and corporations or individuals whose interests are affected thereby, and a final hearing be given them, to the end that your honorable commission may make a final revision of your draft before presenting it to Congress for passage.

Working Up Shop Scrap.

BY G. W. SMITH.

In most contract shops that make a specialty of smokestacks and tanks, the foreman has to keep his wits about him in regard to ordering material. The firm I work for generally gives me the blue print of a job and tells me to let them have a bill of material and also an estimate of about what the labor will amount to on the job. This is pretty plain sailing, but several days ago I had orders to make a smokestack 32 inches in diameter and 80 feet long, and, as it was a rush order, I had to use material from stock the dimensions of which were 48 by 120 by 3/16 inch I found that I would have twenty pieces of metal left over, 3/16 by 17¼ by 48 inches, to go into the scrap heap.

After studying the situation over for a while, I happened to think of a hood and damper for the stack. We wrote to the man who ordered the stack and asked him if he would



LAYOUT OF A HOOD FOR A STACK.

like to have a hood and damper. Of course we showed him the advantages of these, and he replied to the letter requesting that the additional work be done if it would not delay the stack. I used ten of the pieces in the construction of the hood and two in the damper, the other eight were riveted two together and sold to a wholesale grocery house to be used for truckways at the doors for loading and unloading wagons.

The accompanying sketch of the hood is self-explanatory, especially to those who have had any dealing with the cone, and it is hardly worth while to go into details of the explanation, since the cone has been treated in the columns of THE BOILER MAKER on different occasions.

Fig. 1 shows a side view of the hood; Fig. 2 shows the hood as it would appear when looking down on it; Fig. 3 shows the development of the top part of the hood, which is a complete cone in itself; Fig. 4 shows the development of one of the sections of the bottom of the hood. Since there are nine sections in the bottom, and all are the same, the remaining eight can be laid off from this one. The hood made this way was considerably stronger and had a much neater appearance than one made in one or two pieces.

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.

The edition of this issue of The Boiler Maker comprises 5,500 *copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

Apprenticeship Training.

Evidence of substantial progress in the development of modern systems for training apprentices in railroad shops is given in the comprehensive report upon this subject presented at the last convention of master mechanics. According to this report, modern apprenticeship training has been introduced in seventeen shops on four roads during the past year. These roads are the Michigan Central, Santa Fe, Southern Railway and Delaware & Hudson. Two other important roads—the Canadian Pacific and the Erie—have declared their intention of establishing similar systems immediately, and other important roads have the subject under serious consideration. Six roads, including the Grand Trunk, Union Pacific, Boston & Maine, Central Railroad of New Jersey, New York Central and Minneapolis, St. Paul & Sault Ste. Marie, have well-established systems, and report satisfactory progress in the work during the past year. The main features of all these systems consist in carrying out, under the direction of some competent person, a thorough shop training combined with an adequate course of mental training. The mental training or school work is in most cases compulsory, and is carried on during working hours at the expense of the company. The systems developed on this general scheme, with sufficient attention from the heads of departments, and a certain stimulus to the work of the apprentices in the shape of rewards and opportunities for higher education to those showing the most ability, have proved successful in almost every case. This is a subject which is of the utmost importance to boiler makers, since, with the exception of the apprentices in the machine shop, there are usually more apprentices in the boiler department of a railroad repair shop than in all the other departments combined, and their work is of such nature that a certain amount of technical knowledge is necessary for advancement. We quite agree with the statement made by the committee, that the new system of apprenticeship training is the most important influence introduced into railroad organizations during the present generation.

Prizes for Articles on Repair Jobs.

The Boiler Maker herewith offers two prizes, the first of *forty dollars,* and the second of *twenty-five dollars,* for the best articles describing jobs of repair work. The articles need not be restricted to boiler repairs, but may include any repairs to tanks, stacks or other sheet-metal work such as is ordinarily done in a boiler shop.

All articles written in competition for these prizes must be in our hands not later than 12 o'clock noon, March 1, 1909. The award of prizes will be announced at the annual convention of the International Master Boiler Makers' Association, which is to be held at Louisville, Ky., and will be in accord with the decision of a committee consisting of Col. E. D. Meier, president of the American Boiler Manufacturers' Association; P. J. Conrath, president of the International Master Boiler Makers' Association, and J. T. Goodwin, chairman of the executive committee of the International Master Boiler Makers' Association. The articles should not be signed by the competitor's name, but should bear some distinguishing mark and the name of the author be inclosed in a sealed envelope bearing a duplicate of this identification mark. Photographs, drawings and blue prints will be given due consideration in connection with the article, and competitors should remember that such illustrations will add materially to the value of the articles.

Our purpose in establishing this contest is, first of all, educational. There is no kind of work which calls for more skill, ingenuity and thorough knowledge of the trade than repair work. The best men in a boiler shop are always assigned to such work, and a description of how repairs are made is always eagerly sought. In calling particular attention to this branch of boiler making, we feel that we are giving every man who has had any experience in this line a splendid opportunity to help his fellow-workman and at the same time gain for himself a lot of information which would otherwise never be made public. Our readers include the best-trained men in almost every boiler shop in this country, and many who are at work in foreign countries. Their work as a whole covers every possible form of boiler or sheet-metal construction which is ever undertaken in a railway, contract or marine shop. Many of these shops are devoted almost exclusively to repair work, and the men who are employed in them are daily performing work cheaply and efficiently which would seriously tax the resources of a man who seldom or never undertakes a repair job. When it is considered that it is impossible for one man alone, even in the course of a long and busy lifetime, to accumulate more than a very small share of experience in the line of repair work, the value of a suggestion coming here and there from such a large field as is opened up by this contest will be apparent. All of the articles written for this contest will be published either in full or in abstract form in subsequent issues of The Boiler Maker, so that every man who enters the contest, whether or not he succeeds in winning the prize, may feel sure that he is contributing something which will be widely read and appreciated by the men who take an interest in their work and wish to better their positions.

COMMUNICATIONS.

We pay for all contributions to this department which are in any way instructive and of practical value to boiler makers.

Best Method of Cutting Off Rivet Heads.

Editor The Boiler Maker:

I have had twenty-five years' experience in boiler making, and the best form of tool which I have found for cutting off rivet heads is one made just like a backing-out punch, except that it has a half-round nose ground like a gouge. By holding the cutting point of this tool a little past the center of a rivet head it will twist the head off with a very few blows without doing any damage to the plate and the rivet holes.

William Allison.

Air Tools a Time Saver in Boiler Work.

Editor The Boiler Maker:

In all up-to-date boiler shops various kinds of air tools are being used: the air hammer for riveting, calking, chipping, etc.; the motor for drilling, tapping and countersinking, and the jam hammer for bucking up rivets on mud rings and air drums. Air tools are also extremely useful in flue work, as they can be used for rolling, balling over, beading, etc.; but, of course, judgment must be used when using them for such work, as there is danger of overworking the flues, whereas the hand is very sensitive, and tubes can be set by hand without any danger of injuring the tube. Care must be used not to roll the flues too much, just the same as when driving rivets the proper length must be chosen to give a good, full head.

Large air clamps for flanging are also a handy device for forming flue sheets, etc., as the hot sheet can be quickly clamped and then pounded into shape with heavy mauls. The furnace for heating the sheet can be run by oil and air, and with such a furnace the sheet can be heated evenly all over in one heat, and thus a vast amount of time and trouble saved. Also in reaming out, tapping and running in staybolts an air motor saves a vast amount of time. In fact, there is scarcely an air tool built for use in a boiler shop which is not a time saver.

Harry Jewell.

The Value of Boiler Rules and Formulas.

Editor The Boiler Maker:

We are now nearer the goal of thorough boiler inspection than ever before. The number of disastrous explosions which have occurred in the past has not only awakened the officials of our government, but has also aroused the general public to such an extent as to cause them to prevail upon many of the State officials requesting them to have stringent laws passed for the inspection and manufacture of steam boilers. Never before in the history of our country has such interest been displayed in the proper inspection of steam boilers by our people as in the past two years, and it would appear that it is only a question of a short period of time when every State in the Union will be under a boiler-inspection law, and it may be that a Federal law will be the final result. When this time arrives there will be a demand for first-class boiler makers who are possessed of a technical education sufficient to make the necessary calculations on the strength of boilers, men who have a good knowledge of rules and formulas.

The question of how many of our boiler makers will be prepared to serve with credit in this capacity should they be called upon to fill one of these responsible positions will be frequently asked. The excuse of not having the information at hand cannot longer be accepted. Boiler Rules and Formulas by the Master Steam Boiler Makers' Association was compiled from thirty-seven different books, and represents every known authority on boiler construction. It was intended especially for the education and information of boiler makers, and contains almost every rule and formula that a boiler maker will need to ascertain the strength of any part of a boiler, or a mechanical engineer will require to design a boiler. With such a comprehensive source of information at hand anyone who is familiar with the practical side of boiler making and who is ready to exercise a little perseverance in acquiring facility in making calculations on the strength of boilers can fit himself for promotion to a position of responsibility of this kind

T. C. Best.

Plugging a Boiler Tube While Under Way.

Editor The Boiler Maker:

Plugging a leaky boiler tube in a Scotch boiler is not an unusual experience for engineers, especially where old boilers are used which have not been overhauled for many years. When I was chief engineer on board the propeller *Prescott*, plying on the Australian coast, we had no time to lay up at the shipyard for general repairs, and for two years we were never in port for more than one day at a time. The company was short-handed and drove the old *Prescott* year in and year out on the nightly service between Sydney and ————. Her boilers were in bad condition at the time of which I am writing, there being no less than 116 plugged tubes in the four double-ended boilers. Besides this number we had replaced sixty-three tubes. However, though I had reported the condition at the office, the superintendent could not get the boat off for repairs on account of rush of business, and the fact that even in this crippled condition she was making her time. The boilers are 14 feet 3 inches in diameter and 20 feet 6 inches long. There are two corrugated suspension furnaces, 48 inches in diameter by 6 feet 8 inches long in each end of the boiler, each furnace having a separate combustion chamber. The tubes are 2¾ inches outside diameter.

The engineer on watch was always prepared for and expecting a tube to give out, and when this happened, as it usually did when we were under way, we stopped them up without lowering steam by driving into the defective tube a plug of soft white pine, made to fit snug and about 15 inches long. These wooden plugs were removed after the boilers were blown off upon reaching port, and replaced with the usual cast-iron plugs, one at each end of the tube, drawn together by a bar of round iron, with threaded ends passing through tube and plugs and drawn tight at the outside end.

One night we had been delayed on account of heavy freight, and were driving the engines at full speed, when the hissing noise of steam in the furnace of the forward starboard boiler gave notice that another tube had given way. Charlie Baxter was on watch at the time, and it did not take him long to locate about where the leak was. It came from one of three plugged tubes on the lowest tier of the nest, but as it only escaped into the combustion chamber and the outside ends were all tight, we could not tell which of the three was leaking. The leak grew worse and worse, so that soon we had to put on the salt-water feed to make up the loss, and then the plates of the combustion chamber became coated with salt. If that leak was not located and stopped at once we would have to cut off the boiler, which meant reduced speed for many hours. Charlie said he was willing to go in to find the leak if I would have that fire drawn. The one fire was drawn and the grate-bars removed. Bags were laid over the bottom of the furnaces and fire wall, and Charlie crawled in, head first, to the rear of the furnace. All this time the other three furnaces were being fired as usual, and the boiler was supplying steam at the regular pressure of 90 pounds. It did not take him long to find which of the plugged tubes was leaking and to unscrew the nut so that the rod could be drawn out and then crawl out himself. From the fire-room we then drove in a wooden plug, as mentioned above, till it covered the hole in the tube. The steam expanded the soft wood so that a tight patch was made which held all right until reaching port the next morning. Charlie was pretty well used up because of his hot experience, but came around all right in a few hours. It took just an hour to make this repair from the time the fire was drawn till it was relighted, and no time had been lost on the trip. A. S. K.

Patching a Boiler.

Editor The Boiler Maker:

A few good articles have been published recently on the subject of patching a boiler. The thickness of plates and spacing of rivets or patch bolts depend altogether upon where the patch is to be located. Placing a strip of copper under the patch is sometimes a good thing to do, as the copper works under the heads of the patch bolts in the countersink and gives a soft seat for the bolts. A patch located directly over the fire is going to give a good deal of trouble to keep it tight, for the reason that you have a double thickness of plate, which the water will not protect. This is the case in a high-pressure return tubular boiler where the plate is from 13/32 to a ½ inch thick.

Many boiler makers shear the patch and then punch the holes to size, allowing a very small lap. This, in my opinion, makes the patch very weak around the holes, as punching is bound to make the iron brittle. If the holes are already in the boiler, lay a piece of heavy paper over the place where the patch is to be fitted and punch the holes through with the pean of a hammer. Then when marking the holes off on the patch from this paper templet reverse the paper, and you will have the burr-side up for countersinking and the smooth side next to the boiler. A very good way is to lay out the holes on the patch and then drill them slightly small, say 21/32 inch for a ¾-inch patch bolt. Then fit the patch up in good shape, drill one or two holes in the boiler, and, by means of these, bolt the patch up good and tight. Drill the remaining holes right through the patch. This will insure fair holes, and afterwards the holes in the boiler can be tapped out and those in the patch drilled out to 25/32 inch and countersunk. A countersink with considerable taper will make the holes a little larger, but at all events get the heads of the bolts to set in just enough so that they can be plugged down in good shape. Place the patch back on the boiler, run in the bolts and pull them up, nipping and twisting the heads off as you go along. Plug the heads down tightly with the pean of a hammer, or with a plug punch; finally chip and calk them, and you will be sure to have a good, tight job. Of course all this may take a little more time, but you will have a job that is done right in the first place, and, under fair conditions, it will not be necessary to go over it two or three times to make it right. Harry Jewell.

PERSONAL

The Rogers Works of the American Locomotive Company at Paterson, N. J., has been permanently closed.

John Caulfield, formerly layer-out at the Platt Iron Works Company, Dayton, Ohio, has accepted a position as layer-out with the Lackawanna Steel Company, at Buffalo, N. Y.

Henry Pels & Co., manufacturers of universal plate and bar cutters and punches, expect to move their offices from 68 Broad street to 90 West street, New York City, about the middle of November.

A new boiler shop is just being completed for the McDermott Engineering Company, at Allentown, Pa. This firm is composed of two well-known brothers who have served full time at their trade.

George Wagstaff was erroneously reported in our last issue as having become associated with the American Locomotive Equipment Company, of St. Louis, Mo., as their Eastern representative, with offices at 62 Liberty street, New York City. Mr. Wagstaff is at 95 Liberty street, New York, as Eastern representative of the American Locomotive Equipment Company, of Chicago, Ill.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q. 1.—What should be the size of wrought iron and steel stay-bolts to support a ⅝-inch plate carrying 100 pounds steam pressure?
2.—What is the chemical composition of steel plate allowed for boiler shells? J. H. O.

A.—In order to find the size of stay-bolts it is first necessary to find the pitch, since the pitch depends only upon the thickness of the plate and the steam pressure carried, while the size of the stay-bolts depends directly upon the pitch and the steam pressure. The formula for finding the pitch of stay-bolts where the plate is over 7/16 inch thick is

$$p^2 = \frac{120 \times t^2}{P}$$, where p = pitch of stay-bolts in inches; t = thickness of plate in sixteenths of an inch; P = steam pressure in pounds per square inch. Substituting the values given in the question

$$p^2 = \frac{120 \times (10)^2}{100}.$$

$$p^2 = 120.$$

Since the square of the pitch gives the area to be supported by one bolt, the total pressure to be supported by one bolt can be found by multiplying this area by the steam pressure. Or, $p^2 \times P$ = 12,000 pounds. Therefore, the area of the bolt times the allowable tensile stress which the bolt may safely carry should be made equal to 12,000 pounds. The allowable stress in a short stay-bolt should not be more than 6,000 pounds per square inch. Therefore, the area of the bolt times 6,000 = 12,000; or the area = 2 square inches. Hence the diameter of the bolt is found to be 1.7 inches.

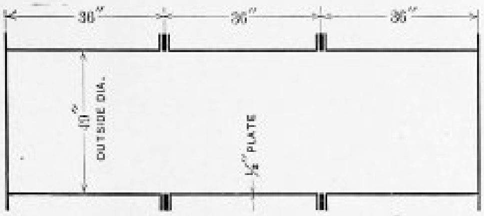
2.—For the shells of steam boilers the grade of steel usually classed as open-hearth fire-box steel should be used. This, according to the rules of the American Boiler Manufacturers' Association, which may be said to represent the best practice, should have a tensile strength of from 52,000 to 62,000 pounds per square inch, a yield point at least one-half the tensile strength and an elongation in a gaged length of 8 inches of 26 percent. The percentage of phosphorus should not be more than .035, and of sulphur not more than .035, of manganese from .30 to .050; while the percentage of carbon will be governed by the physical properties.

The rules of the United States Steamboat Boiler Inspection Service allow steel of from 50,000 to 75,000 pounds per square inch tensile strength with a 25 percent elongation to be used for boiler shells, the percentage of phosphorus in such steel when made by the acid process being not more than .06, and when made by the basic process not more than .04, while the percentage of sulphur for either process should not be more than .04.

Q.—What is the correct formula for determining the safe working pressure on an Adamson furnace? What is Lloyd's formula for this? C. B. S.

A.—The rule specified by the United States Steamboat Boiler Inspection Service is as follows:

$$P = \frac{C \times T^2}{L \times D}$$, where P = working pressure in pounds per square inch; C = 89,600, where the distance between rings is not more than 8 feet; T = thickness of plate in inches,



SECTION OF ADAMSON FURNACE.

which must not be less than 5/16 inch; L = distance between rings in feet, and D = outside diameter in inches. For the furnace shown in the sketch this formula figures out

$$P = \frac{89{,}600 \times (\frac{1}{2})^2}{3 \times 49}.$$

P = 152.4 pounds.

Lloyd's rule, where the length of a flat portion of the furnace, that is, the distance between flanges, is greater than 120 times the thickness of the plate, is

$$P = \frac{1{,}075{,}200 \times T^2}{L \times D}$$, but where the length of the straight portion is less than 120 times the thickness of the plate;

$$P = 50 \times \frac{(300\ T - L)}{D}$$, where D = outside diameter in inches; T = thickness of plate in inches; L = length of plain cylindrical part in inches, measured from the commencement of the curvature of the flanges of the furnace where the rings are fitted. For the furnace in the sketch, $120 \times T = 60$ inches. This is greater than the length of one section of the furnace; and, therefore, the second formula should be used. Since the length of one section of the furnace is 36 inches, the length of the straight portion of the furnace between the flanges would be about 33 inches. The formula would work out as follows:

$$P = 50 \times \frac{(300 \times .5 - 33)}{49}.$$

P = 119.4 pounds.

Q.—We are very frequently called upon to roll leaky tubes in an upright boiler, and have exhausted about all methods, except using stay tubes or staying the heads, without being able to stop the tubes from leaking in the fire box for more than a few days at a time. The boiler is of the Manning type, with a 74-inch fire box, and contains 284 2½-inch lapwelded steel tubes 15 feet long, beaded at both ends. A steam pressure of 90 pounds is maintained by means of a blower system. When this system is not used and natural draft is substituted the tubes remain tight a few days longer than when the blower is used. We believe the leaking is caused by the expansion and contraction of the head, and that the common steel tubes used do not hold the head rigidly enough to prevent this expansion and contraction. Also that the expansion and contraction of the two heads are not the same, the tube sheet in the fire box expanding and contracting more than the top head, which must necessarily cause the tube to slip in the tube sheet. We should be glad to hear of any method by which we can perevent this leakage. H. G.

A.—The only solution of the foregoing question is that the boiler is either dirty or the furnace is so arranged that the heat is concentrated in one locality. In twenty-six years' experience with about two hundred of these boilers, I have never had a leaky tube in a clean boiler.

Within a month I have just taken out the first Manning boiler ever built. This boiler was in steady use over twenty-five years, and was only renewed because it was desired to raise the steam pressure to 175 pounds, whereas the original boiler was designed for only 100 pounds, which it had carried up to the day it was taken out. There was not a leaky tube in this boiler. Recently a boiler maker was sent out to examine two boilers of this type which were giving trouble with leaky flues. The boiler maker found 2 inches of mud on the tube sheet, *not scale but mud.* Water that is unfit to use in this boiler is unfit for any boiler, the only difference being that on this one it starts tubes to leaking, whereas in a horizontal return tubular boiler it is likely to cause the sheets to bag.

If the boiler complained of is thoroughly cleaned on the lower tube sheet there will be no further need of rolling the tubes or developing theories of unequal expansion and contraction. Five years ago forty of these boilers were installed in one plant, and for a time the rate of combustion was as high as 27 pounds of coal per square foot of grate area, which was maintained with a Jones stoker and fan blower. It has never been necessary to roll a tube in these boilers since they were started.

I never have a tube beaded at either end, for with a tube properly rolled it is tighter before beading than after. The rolling will prevent the tube from slipping up to a pressure of 3,000 pounds (in the case of a 2½-tube in a ½-inch sheet), and the tube pulls out slowly as the pressure increases. If the tube is beaded it will stand a pressure of 24,000 pounds, and then will give way with a snap, the tube generally breaking about the middle of the sheet. In beading the tube, four out of five are split clear in past the tube sheet, and the tube must of necessity be somewhat loosened in the tube hole, although a good workman will close up the cracks and leave a very good-looking job when it is finished.

CHARLES H. MANNING.

ENGINEERING SPECIALTIES.

The "Use-Em-Up" Drill Socket.

Among the late improvements in shop appliances the "Use-Em-Up" drill socket, made by the American Specialty Company, 1440 Monadnock building, Chicago, seems to be one of the most simple and at the same time one of the most efficient and useful. The present method of driving taper shank drills and reamers has been the cause of an enormous loss both in the tools themselves and in time. Theoretically, the drill or reamer is driven by the friction between the taper portion of the drill and the socket in which it is used, the tang being merely to facilitate driving the drill out of the

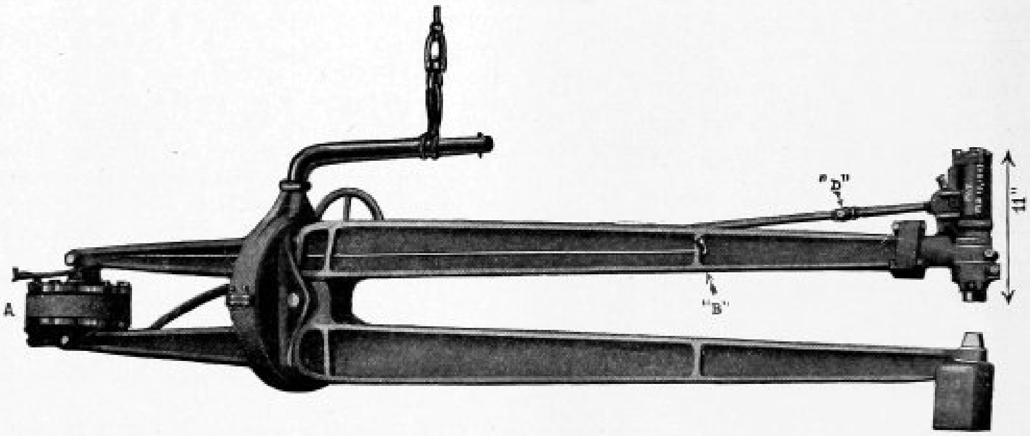
socket or spindle. In practice, however, this does not hold true, as the taper on the drills and sockets is not absolutely accurate, and therefore it devolves upon the tang to do the driving, with the result that it is either twisted off or the shank broken. When a flat has been ground on the shank of the drill or reamer, either new or old, it may be used with the "Use-Em-Up" drill socket, and it is claimed that the drive is absolutely positive, *even if there is only ½ or ¾ inch of shank left on the drill.* The amount ground off the shank has no effect on the drill running true, as it must center itself by the cylindrical portion no matter how much or how little is ground off.

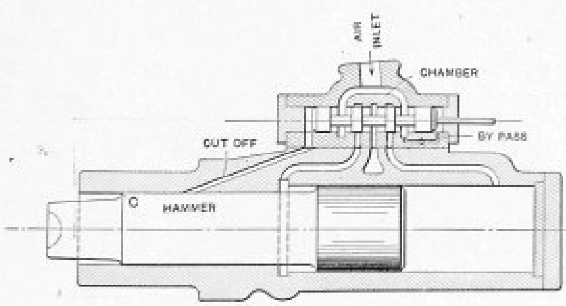
That there has long been a field for such a tool is shown by the large number of complicated and expensive chucks and kindred devices which have been put on the market during the last few years to accomplish this purpose. The socket referred to could hardly be more simple, as it is in one solid piece, and differs from an ordinary standard drill socket only in the flat portion, which can be seen in the illustration. We are informed by this company that during the last four months this socket has been put into use by ninety-one railroads, as well as seven locomotive companies, and hundreds of other shops experiencing trouble of this kind.

The Allen Portable Pneumatic Boiler Riveter.

The design of the Allen portable pneumatic boiler riveter has recently been improved by substituting a new form of a valve controlling the admission of air to the riveting cylinder.

The riveting machine proper consists of a cylinder containing a piston, to which is attached the hammer head, or die. As can be seen from the line cut, showing a section of the cylinder and valve, the piston and hammer head are in one piece. This is made of tool steel, and the hammer head is hardened while the piston itself is left soft. The diameter of the piston rod is ½ inch less than the diameter of the piston itself, so there is sufficient area at the hammer end of the piston for the air pressure to force the piston back on its return stroke. From the line cut it will be seen that the air enters a valve chamber, containing a piston valve on which are four separate pistons. The full air pressure always exists in the space between the two outer and inner pistons. When the valve is in mid-position the inner pistons just cover the ports leading to the riveting cylinder. Any movement of the valve in either direction will cause air to be admitted at one end of the cylinder and exhausted from the other end. The action of the valve is controlled automatically by means of a cut-off passage at one end and a by-pass at the other. When the riveting hammer is at the top of its stroke ready to strike a blow, the cut-off port is open to the atmosphere, and there is atmospheric pressure at the left-hand end of the valve. At the same time, it will be seen that there is a greater pressure than that of the atmosphere on the right-hand end of the valve, since there is a small by-pass leading from the air chamber to the end of the valve cylinder. This by-pass is almost entirely closed by a small screw. The amount of the opening can, of course, be adjusted to suit the requirements of the machine. When the hammer descends on its working stroke, as soon as the shoulder *C* passes the cut-off opening the pressure at the left-hand end of the valve immediately rises, since the valve itself is traveling towards the left. When the pressure is great enough to overcome the pressure of the other end the valve moves back again and the hammer is returned.





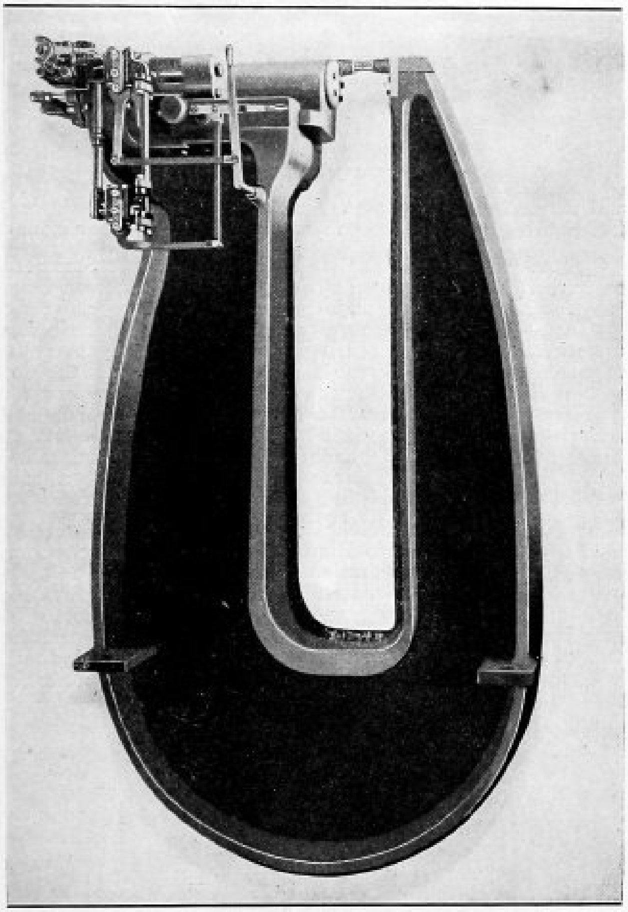
It will be seen that the action of the valve is entirely automatic, and, since its movement is slight, wear is reduced to a minimum. Furthermore, the effects of any slight leakage can be overcome by adjusting the opening in the by-pass.

This device was patented in 1907 by John F. Allen, manufacturer of these riveters, at 370 Gerard avenue, New York. It works with great rapidity without damaging the sheets. In the tapet cylinder previously in use the valve was moved mechanically, and, therefore, the mechanism is subject to wear. The tapet cylinders are still used on the larger-sized machines, but the automatic cylinders have been placed on the machines capable of driving ½, ¾ and 1-inch hot rivets and ⅜ and ½-inch cold rivets.

The Chambersburg Hydraulic Riveters.

The Chambersburg hydraulic riveter shown in the illustration is the latest and most improved model as built by the Chambersburg Engineering Company, Chambersburg, Pa., for general boiler shop work, and is arranged for three or five multiple pressures. The various pressures are obtained by means of a patented distributing valve, which admits the water under pressure to the proper cylinder to give the tonnage desired on the rivet. The lever for operating this valve is mounted on an index plate, which shows absolutely the pressure that will be given with the lever in the various positions. By this patented arrangement the minimum amount of water is used when the machine is set for the lowest tonnage, and the greatest amount of water only when the machine is being operated at its maximum tonnage. It is this feature of economy in the use of hydraulic power that has given the Chambersburg riveter its popularity. The machine is of the simplest design throughout, and has large wearing surfaces, being so arranged that all wear may be taken up and the riveter kept in alignment. The main operating valve seats metal to metal and has bronze removable seats. All rams and valves are outside-hemp packed, the glands being easily accessible, and it is not necessary to take the machine apart to repack. The machine has a hydraulic pull back under constant pressure, and is very rapid in operation, giving a large production.

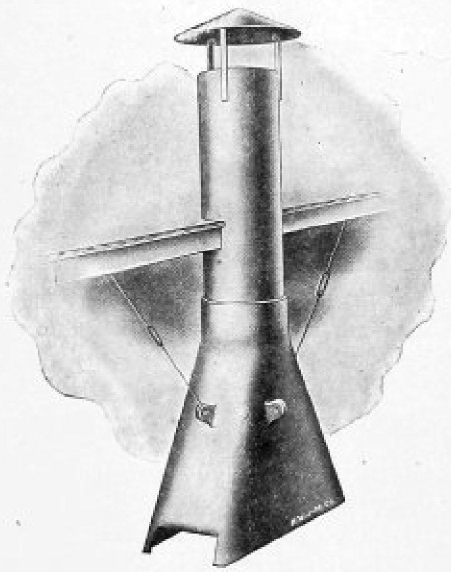
The machine is flush, too, as shown by the illustration, permitting flanged work to be riveted. The crane valve is also shown attached to the riveter frame, so that both crane and riveter can be operated by one man without changing his position.



In addition to supplying the complete riveter this company has attached its patented hemp-packed heads to a number of old-style leather-packed hydraulic riveters of other makes, the resultant saving in amount of pressure water required, and low cost of packings, etc., paying for the new head in a short time. The Chambersburg heads have also replaced a number of steam heads.

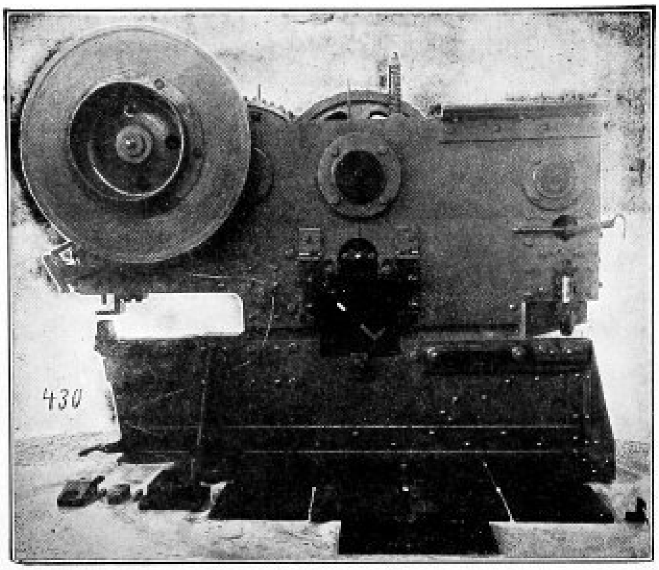
An Indestructible Smoke Jack.

The H. W. Johns-Manville Company, of New York, has just placed on the market a new fireproof smoke jack known as the "Phœnix," which differs from the ordinary "built-up" jack, because it is not made of many pieces held together with flanges and bolts, but consists of only three separate and distinct parts, each of which is in one piece without a seam or joint of any kind. It is made of a fireproof, plastic material, which is moulded into the desired shape and sets hard in a few hours. When thoroughly dry it is almost as hard as iron, and is extremely strong and durable. It is claimed that the materials used in its construction are absolutely fire and acid proof, and that the jack is not affected in any way by heat, moisture, acids or the gases of combustion. The entire jack is reinforced with extra heavy galvanized iron wire cloth, which is imbedded in the material and gives it exceptional strength and rigidity. When first assembled the jack consists of three parts, the hood, the circular stack and the cowl, all of which are finally fastened together with Phœnix compound in plastic state, producing a one-piece jack. It is supported entirely by hanging rods attached to eye openings in the hood. These openings are made of the same material as the jack, and are reinforced with heavy wire cable, the ends of which are unraveled and interwoven with the wire cloth. This makes the eyes strong enough to sustain the weight of the entire jack, and by spreading the rods attached thereto the weight becomes distributed over a large area of the roof. After the jack is in place these rods are covered with Phœnix compound to prevent deterioration. The interior of the jack is perfectly smooth, without any protruding bolt heads or flanges, and it offers, therefore, an unobstructed and smooth surface, with no tendency to prevent the escape of the smoke. The average thickness of the jack is ⅝ inch, and the weight from 4 to 4½ pounds to the square foot.



Triple Punch, Shear and Cutter.

This machine, manufactured by Henry Pels & Co., 68 Broad street, New York, is a complete boiler-shop equipment in itself, and has been designed to meet any requirement of up-to-date boiler-shop practice. The splitting shear will shear plates of unlimited length or width; any depth of throat can be furnished on the punch end, and the bar cutter head can be fitted with knives to shear rounds, squares, angles and tees without change. Each head can be operated independently by means of gags. There has been considerable prejudice against combination machines of this type manufactured of cast iron, owing to breakage in the frames, but this machine is built up of mild steel plates from 2 to 5 inches in thickness, varying with its capacity, so that the frame is practically unbreakable. Both the straight and tangent channels through which the sheared plate passes are milled out of the main frame, and have no fillets usual in cast iron machines. There is no cramping or buckling of plates in consequence, and the plate is fed with ease. The punch can be adjusted to punch continuously, or stop automatically at the end of each stroke. The length of stroke can be regulated, and the punch can be lowered to center mark for accurate work without throwing the machine in gear. The punch end is built with an architectural jaw, to permit the punching of flanges of I beams, channels, etc., and it is also possible to bevel angles and tee bars up to 45 de-



grees right or left on the bar cutter. This machine is built in six sizes, with plate-shearing capacities from ½ to 1¼ inches; punch, ⅞, ½ inch to 1½ by 1¼ inch.

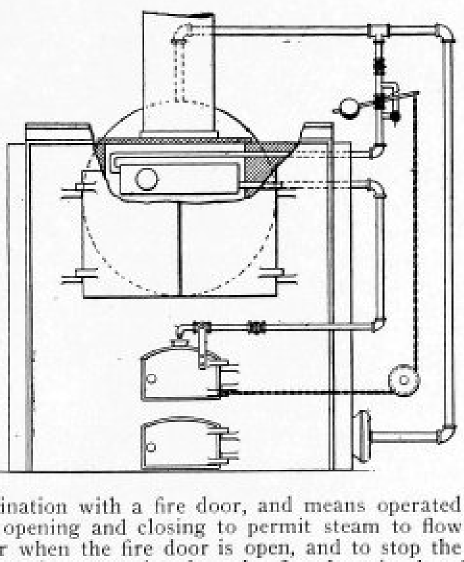
SELECTED BOILER PATENTS.

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.

899,102. AIR REGULATOR FOR FURNACES. Alfred Cotton, of Newark, N. J.

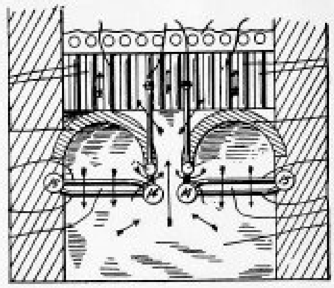
Claim.—An air regulator for a furnace comprising a reservoir, means for supplying steam to said reservoir, a pipe leading the steam from said reservoir to the fire in the furnace,



in combination with a fire door, and means operated by said door in opening and closing to permit steam to flow to said reservoir when the fire door is open, and to stop the flow of steam to said reservoir when the fire door is closed. Nine claims.

892,613. DOWN-DRAFT FURNACE. Orel D. Orvis, of Jersey City, N. J., assignor to Arvis Smoke Controller Company, of New York, N. Y.

Claim.—In a down-draft furnace the combination of a boiler, inclined water tubes, side headers connected to said tubes, central headers connected to said boiler, arches supported on said central headers. other central headers, a water grate formed between the latter and the said side headers, connections between said central headers, the said water grate comprising a plurality of water tubes located at different levels and expanded into the last-mentioned central headers



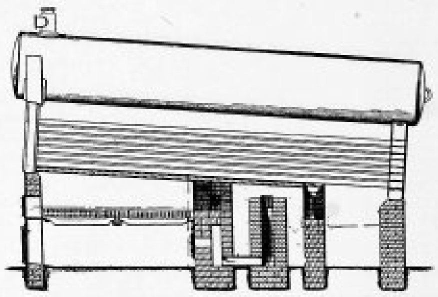
and the said side headers, and connections between said central headers and the water tubes of the boiler. Four claims.

897,322. WATER-TUBE BOILER. Leland L. Summers, of Barberton, Ohio, assignor to the Babcock & Wilcox Company, of New York, N. Y., a corporation of New Jersey.

Claim.—In a water-tube generator of the class described, a reverberatory arch or covering extending partially over the furnace, an upward passage for the gases between the end wall of the furnace and the reverberatory arch or covering, a transverse vertical baffle or bafflings extending upwardly and entirely across the tubes in a vertical direction, but leaving clear spaces at each side, and subsequent longitudinal baffles or baffling arranged to cause the gases to follow a path parallel with the tubes of the generator. Seven claims.

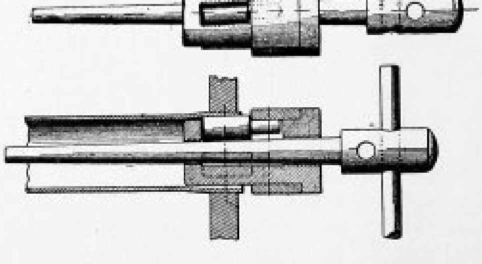
897,446. BOILER-FURNACE. Orestes U. Bean, of New York, N. Y., assignor to Bunsen Smokeless Furnace Company of America, a corporation of South Dakota.

Claim.—In a boiler furnace the combination with a fire-box, of a bridge wall in the rear of said fire-box, a combustion chamber in the rear of said bridge wall, a series of piers separated from each other mounted on top of the bridge wall and extending from the top of the bridge wall to the lower



surface of the boiler, whereby a plurality of restricted openings are formed for the passage of the products of combustion, a second series of piers located adjacent to the bridge wall and extending from the bottom of the combustion chamber to a height less than the height of the top of the first-mentioned piers and in line with the restricted openings between the first series of piers, said bridge wall being provided with an air chamber, and both of said series of piers being provided with air channels having suitable outlets and connected to the air chamber in the bridge wall. Seven claims.

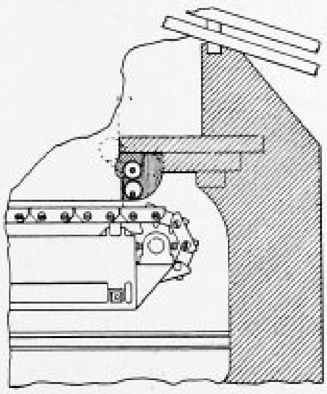
898,202. BOILER-TUBE EXPANDER. John W. Faessler, of Moberly, Mo.



Claim.—The herein-described boiler-tube expander, comprising the cylindrical body, through the center of which is formed a longitudinally-disposed opening, the flange formed integral with the rear end of the body, there being a series of radially-arranged openings formed through the body and communicating with the opening therethrough, the ring loosely mounted on the rear portion of the body and inclosing the rear portions of the radially-arranged openings and which ring is of the same diameter as is the flange on the rear end of the body, the rollers loosely arranged in the radially-arranged openings, the rear ends of which rollers bear against the front face of the ring, the stems integral with the rollers, which stems bear against the inner periphery of the ring, a tapered spindle adapted to pass through the opening in the cylindrical head and engage all of the rollers, and a handle detachably applied to the outer end of the spindle. One claim.

898,101. TRAVELING-GRATE FURNACE. Joseph Harrington, of Chicago, Ill., assignor to Green Engineering Company, of Chicago, a corporation of Illinois.

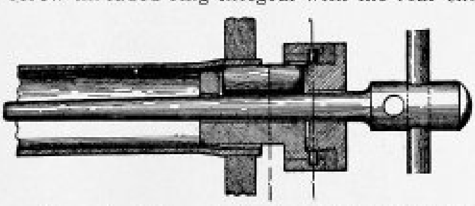
Claim.—The combination with a traveling furnace grate and a bridge wall having a part which projects forwardly over said grate, of a pivotally mounted, adjustable bridge



piece between the wall and grate, the overhanging part of the bridge wall being provided with a convexly-curved, downwardly-facing bearing surface adapted for contact with the bridge piece in all positions of the latter. Twenty-one claims.

898,203. BOILER-TUBE EXPANDER. John W. Faessler, of Moberly, Mo.

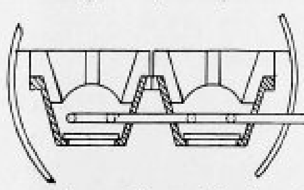
Claim.—A tube expander, comprising a cylindrical body, through the center of which is formed a longitudinally-extending opening and said body being provided with a plurality of roller openings, rollers located in said openings, an internally screw-threaded ring integral with the rear end of the



body, a portion of which ring incloses the rear ends of the rollers; a ring arranged for rotation on the first-mentioned ring, there being a continuous annular groove formed in the inner face of the second-mentioned ring, a pair of oppositely-arranged pins passing through the first-mentioned ring and engaging in the groove, and a screw plug seated in the screw-threaded ring, the inner end of which screw plug normally covers the inner ends of the pins. Three claims.

899,910. GRATE FOR THE FURNACES OF STEAM BOILERS. Henry Schofield, of Sheffield, England.

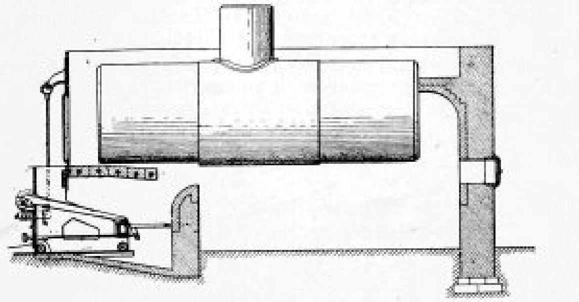
Claim.—In steam boiler furnaces the combination with longitudinally-extending trough-shaped air conduits having



downwardly-converging walls and having their upper edges flanged outwardly, of transversely arranged fire-bars having converging depending portions conforming to and fitting closely within the conduits, and having end projections which rest on said conduit flanges, said fire bars being formed with vertical and inclined spacing abutments, producing vertical tapering air passages. One claim.

899,053. FURNACE. Aaron Jay, of Chicago, Ill.

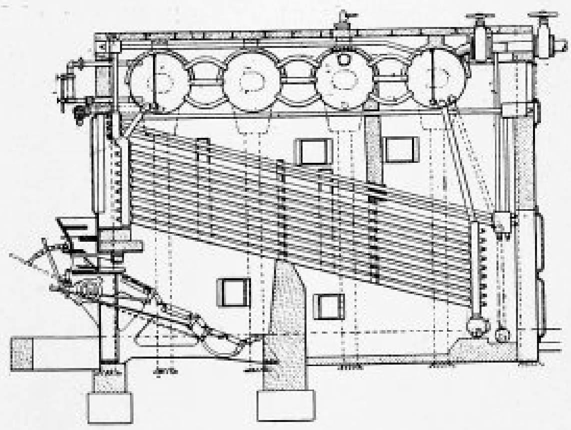
Claim.—In a furnace, the fire chamber, the combustion chamber communicating with said fire chamber at their upper parts, a bridge-wall separating the lower parts of the fire and combustion chambers, a removable carriage in the front part



of the fire chamber, grate-bars movably mounted on said carriage, means for oscillating said grate-bars to feed the fuel into the fire chamber, a secondary grate hinged to said bridge-wall at the rear of said carriage to receive the fuel from the grate-bars, and a rod connected with said secondary grate for operating the same extending through and detachable from said carriage so that the latter can be moved clear of the rod. Two claims.

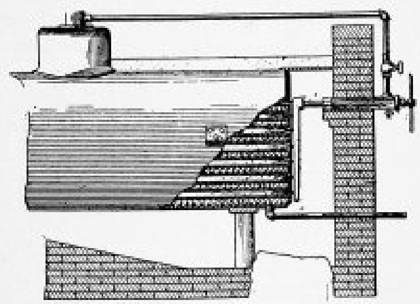
899,060. SUPERHEATER. Julius H. Meissner, of Pittsburg, Pa.

Claim.—The combination with a boiler, of a tubular superheater comprising a set of horizontal tubes and a set of inclined tubes communicating at both ends, and having such



ends adjacent to and accessible from the ends of the boiler, together with means whereby the steam from the boiler is passed through the superheater, and means for filling the superheater with water from the boiler whereby the superheater may be used as a generator. Eight claims.

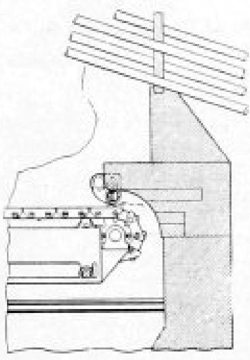
899,261. BOILER CLEANER. Charles H. Prescott, of East Liverpool, Ohio.



Claim.—The combination of a boiler provided with flues and having a wall opposite one end thereof, a chest mounted in the wall, a pipe extending loosely through the inner end of the chest and communicating with the interior thereof; a steam pipe leading to the chest, a lateral arm carried by the pipe and having a triangular cross section, the end of the lateral arm being open, and one of the longitudinal edges of the said arm being formed with a series of jet openings, a removable plug for the open end of the arm, and means for rotating the pipe to swing the lateral arm across the end of the boiler so that the steam jets issuing therefrom will pass through the flues. Two claims.

898,468. TRAVELING-GRATE FURNACE. Joseph Harrington, of Chicago, Ill., assignor to Green Engineering Company, of Chicago, a corporation of Illinois.

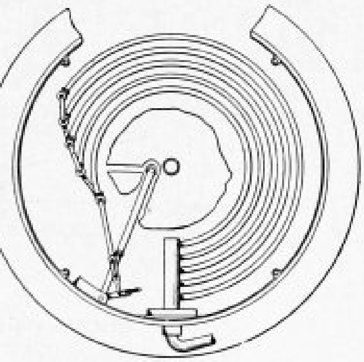
Claim.—The combination with the side walls of a furnace, of a bridge wall provided with an overhanging part, a tubular metal bridge piece of cylindric form, provided at its ends with



eccentric trunnions, and supporting plates in said side walls for said trunnions, the trunnion at one end of said bridge piece being tubular and forming part of the passage by which water is supplied to the interior of the bridge piece. Seven claims.

899,932. PRESSURE GAGE. Eben S. Wheeler, of Detroit, Mich.

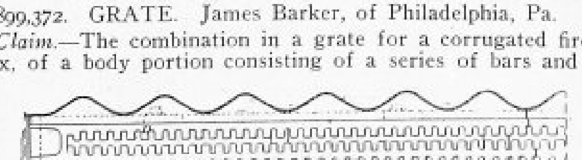
Claim.—In a pressure gage, in combination with a manifold, a plurality of coaxially arranged Bourdon tubes communicating therewith, a rock shaft, links connecting the free ends of



the Bourdon tubes to the rock shaft, whereby the united action of the tubes is communicated to the shaft, and means actuated by the shaft for recording the movement thereof and thereby of said Bourdon tubes. Three claims.

899,372. GRATE. James Barker, of Philadelphia, Pa.

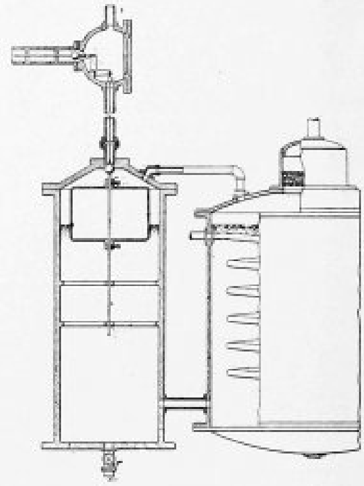
Claim.—The combination in a grate for a corrugated fire-box, of a body portion consisting of a series of bars and a



side section at each side of the body portion, each side section having an undulated edge to conform to the corrugations of the fire-box, said side sections being arranged so that they can be moved longitudinally in respect to the body portion of the grate, and means for securing the side sections to the body portion after adjustment Five claims.

898,625. FEED-WATER REGULATOR. Walter H. Bartholomew, of East Orange, N. J., assignor to Charles B. Hill, Trustee, of Montgomery, N. Y.

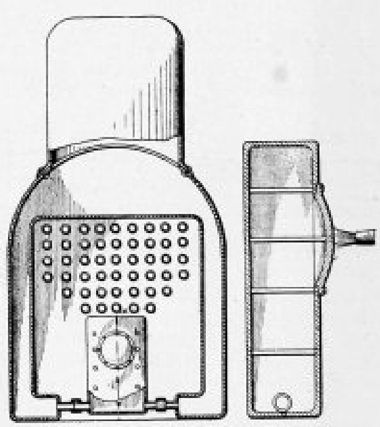
Claim.—A device for automatically regulating the supply of feed water, a receptacle, a chamber overlying said receptacle and connected thereto, a supply conduit for said chamber, an outlet leading from said chamber, a valve in said outlet, a



valve in the connection between said chamber and receptacle, said valves being arranged to receive pressure from the water in said chamber, operating means disposed between said valves and connected to each, and a float connected to said valve between the chamber and receptacle. Eight claims.

898,662. BAFFLE FOR OIL-BURNING FURNACES IN STEAM ENGINES. Joshua Limerick, of West Medford, Mass.

Claim.—A target for use in connection with a liquid fuel burner, said target having a part of its wall made spherically



convex to receive the direct action of the flame and spread the same in all directions, said spherically convex portion being thicker than the remaining portion of the wall. Two claims.

899,948. WATER-TUBE CIRCULATING STEAM BOILER. Percy W. Burke, of Chicago, Ill.

Claim.—The combination with a fire-tube steam boiler, of a blow-off pipe connecting with the bottom at the rear end of the same and extending down through the smoke chamber back of the bridge wall and having a valve, a flat horizontal coil or serpentine at the grate level and extending approximately the width and length of the fire-box and smoke chamber, and having connection by two pipes with said blow-off pipe for feeding water to the coils, a vertical coil or serpentine lining the wall on each side of the fire-box and smoke chamber and connecting with said flat coil, and, on opposite sides, with one end of the fire-tube boiler, and a shaking grate having the bars thereof placed between the water-tubes of the horizontal coil. Three claims.

THE BOILER MAKER

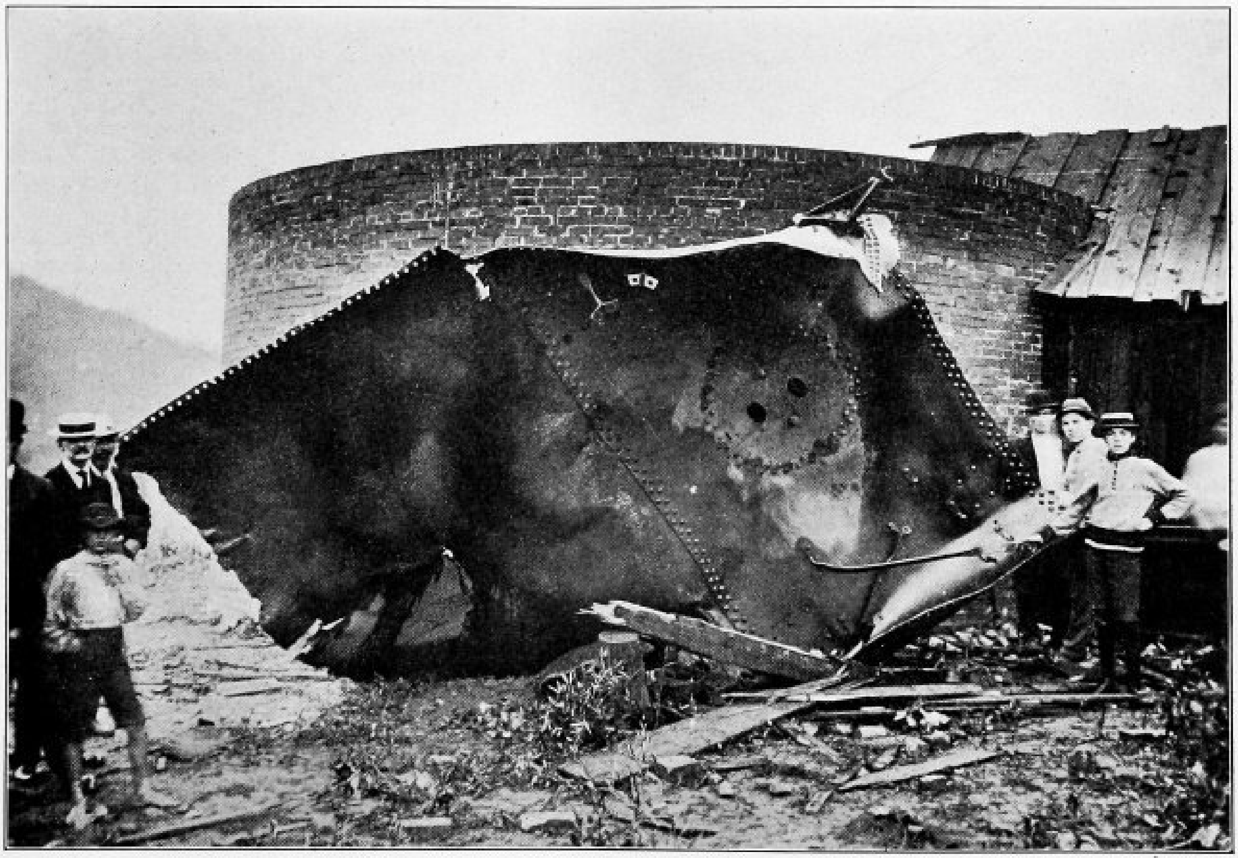
VOL. VIII DECEMBER, 1908 No. 12

Steam Boiler Inspection.

BY C. M. HANSEN.

Should all stationary steam-boiler construction and inspection be governed by State or Federal restrictions, and should a universal engineers' license law be enacted? If I were asked the above questions my answer would be most emphatically in the affirmative, and I will in the following try to show a few reasons why this should be so.

What causes boiler explosions? This question has recently been thoroughly exploited in this paper and in a number of others by various authorities. One states the greatest number of explosions is due to scale formation; another to deterioration or corrosion of plates; still another, to low water, etc. I contend they are all wrong. It is a broad statement, but there



SECTION OF BOILER SHELL FROM EXPLODED BOILER AT MONONGAHELA CITY, PA.

The idea is by no means new; it has for years been advocated especially by the American Boiler Manufacturers' Association. Their work towards this most desirable end has been quite extensive, and at their recent convention at Atlantic City it occupied a considerable portion of their session. There are, however, other parties as vitally interested in this matter as the boiler manufacturer, viz.: our engineering societies, insurance companies, and particularly the steam users. These bodies should lose no time in doing their share of work towards this much-needed reform, for it cannot be accomplished too soon.

is plenty of evidence to substantiate it. All of the above-named causes are but secondary. The primary cause of 95 percent of boiler explosions in the United States to-day is pure and simple negligence; the remaining 5 percent to be attributed to conditions above human control and which, of course, cannot be prevented.

After a recent explosion killing ten and crippling twenty, it was stated upon good authority that the boiler in question had been operated for years without a steam gage, and that nobody had ever heard the safety valve blow. Does it seem feasible that such conditions can exist in this which we proudly term the most advanced nation in engineering? No, it does not, but facts show us that such is the case, and it is but one instance of many; there are hundreds of steam boilers in the United States to-day that are literally not safe to boil water in, much less to work under pressure, and they would, if given an impartial examination, be put out of existence. In the above case it was also stated that the boiler in question had been inspected two weeks previous to the explosion by an *expert* inspector, and pronounced in good condition. If such was the case the so-called expert inspector, together with all other responsible parties to the accident, should without question have been indicted for manslaughter, as fragments of boiler after explosion clearly showed that it required no microscopic examination to discover that it was in a very dangerous condition. The fact that there was no steam gage and that the safety valve did not work was sufficient reason for an inspector to prohibit the boiler being run until these defects were remedied.

PROPER CONDITIONS FOR INSPECTION OF A STEAM PLANT.

But now the question arises: with the prevailing lack of law, under what conditions are the inspectors in many places called upon to make the examination, and how should conditions be?

In a great number of plants the boiler capacity is from 25 to 50 percent short (due in many instances to the fact that they are run in such a condition that but from 50 percent to 75 percent of the actual efficiency is derived). The steam user or plant owner states he can not possibly afford to shut down for a day to have his plant inspected; still the same man can afford to operate the same plant for 365 days out of the year with the decreased efficiency as stated above. How inconsistent with modern business principles!

In some instances the inspector possesses tact and diplomacy enough to convince the owner that an inspection is absolutely necessary, but if he does not possess these qualities he must take the boilers at such time and under such conditions as the owner sees fit. If he can not be there on Sunday (and it is evident he cannot be everywhere on that day) he must take them at night; that means the boiler is under pressure until 5 or 6 P. M., and must be ready again for service at 6 A. M. In the intervening twelve hours the boiler must be blown down, cooled, scaled, washed, inspected, filled again and fired up; it is obvious that under such conditions inspection becomes a mere farce. I am here referring to States where insufficient or no legislation relative to boiler inspection is in force.

Let it be understood in the above that I am not charging all plant owners; there are a great number of them who are anxious to have a thorough inspection made, but the number to the contrary is legion.

At its best it takes approximately twelve hours for a boiler to cool sufficiently to permit a man to stay in it long enough to make a thorough inspection, unless it is cooled artificially by running cold water in it, which I know is widely done, but should never be allowed, as it is sure to prove detrimental to the boiler. If it is coated with scale, that should all be removed; also the combustion chamber and all accessible parts should be thoroughly cleaned before the inspector is called upon to examine it.

It appeals to reason that in order to inspect anything we must see the thing itself, not the surroundings. Inspecting a boiler coated internally with heavy scale and covered externally with soot, dirt and ashes will give about the same results as if a mine inspector walked over the ground where the mine was situated underneath. When sending in his report he would not know what he was talking about as far as the mine was concerned; he could state only condition of surroundings. It is the same with the boiler inspector, and the result is very poor indeed, as the company and the people at large are interested in knowing whether or not the boiler is in a safe working condition.

We will not be too hard on the plant owner, for he is operating his plant according to law, or rather, according to lack of law. He may be morally wrong, but he is legally justified, even if his boilers blow up and wreck the whole community—an obvious reason why suitable legislation should be enacted.

LICENSING ENGINEERS.

Let us assume that a law was enacted and subsequently enforced governing in the first place construction of the boilers, and next, inspection of same at regular intervals under conditions that would permit inspection in the true sense of the word, would it then entirely safeguard us against explosions? No, we still have another factor to deal with, viz.: the fallibility of man, or, in other words, the negligence of the inspector and engineers; therefore it becomes necessary to elevate them to the highest possible standard, and the best medium for that purpose is a universal license law, or compulsory study. Such a law is plainly a necessity. The careless and ignorant so-called engineer is our greatest source of danger. Having an inspector come around should not convey to anyone's mind the idea that he is responsible for the safety of the boilers; he is merely acting as a checker of the engineer's work, and can only vouch for the condition of the boiler on the date of inspection. A careless engineer could easily blow up the boiler the following day, which goes to show that the greater responsibility rests on him.

During a recent conversation with the owner of a large steam plant he used the following expression: "The idea of making engineers from books is all bosh." I agree with him to a certain extent. A thorough practical training is an absolute necessity in the make-up of a good engineer, but so is a thorough technical training. This very man mentioned above could, if he would employ a man who thoroughly understood the art of burning coal, accomplish a saving of thirty-seven dollars and fifty cents ($37.50) daily on his coal bill alone. The coal consumption in this plant aggregates 75 tons per day, at a cost of $1.50 per ton, or a total of $112.50, whereas, if the management of the plant was in the hands of a man who thoroughly understood his business, or in other words, a man that, together with his practical training, had sufficient theoretical knowledge to be able to apply it to his practice in utilizing every heat unit developed in his furnaces for generating steam, instead of merely having his firemen shovel coal for the sake of burning it, a saving of at least 33⅓ percent could be effected.

We talk about wasting coal—here is a problem to solve for the commission appointed to investigate how to preserve our natural resources.

Under all conditions and in all stations of life, study always makes a man better, and if a man starts on any career without having the top of his profession as his goal he is a failure from the beginning. There are many men and boys who tell us they are too busy to study; these persons are usually the ones we see every night frequenting our billiard halls and barrooms. It is only the idle that have no time. The real busy man can always find an extra hour for extra work, and if our young mechanics knew that in order to become an engineer they must know more than that water in boiler plus fire plus turning a valve stem makes the engine run they would soon get a taste for study.

There are at the present time a great number of municipal ordinances governing both boiler inspection and also engineers' license. As far as the inspection is concerned, the majority of them are of no value whatever. They are largely controlled by political machines; men are being appointed to the positions whether they are suited for it or not; their sole qualifications in many instances are theirs or their friends' political influence. Consequently the steam user, knowing this, is only reluctantly paying the prescribed fee for inspection, knowing he is getting no return for his money, and is usually, if he takes any interest in his plant, resorting to the insurance companies in order through their inspectors to get a true condition of same. Let us get it on a competitive basis; don't let the mere fact that a man has political influence be enough to qualify him for so important a position. Getting it to the point where the best man would get the position would promote study and make better men of us all.

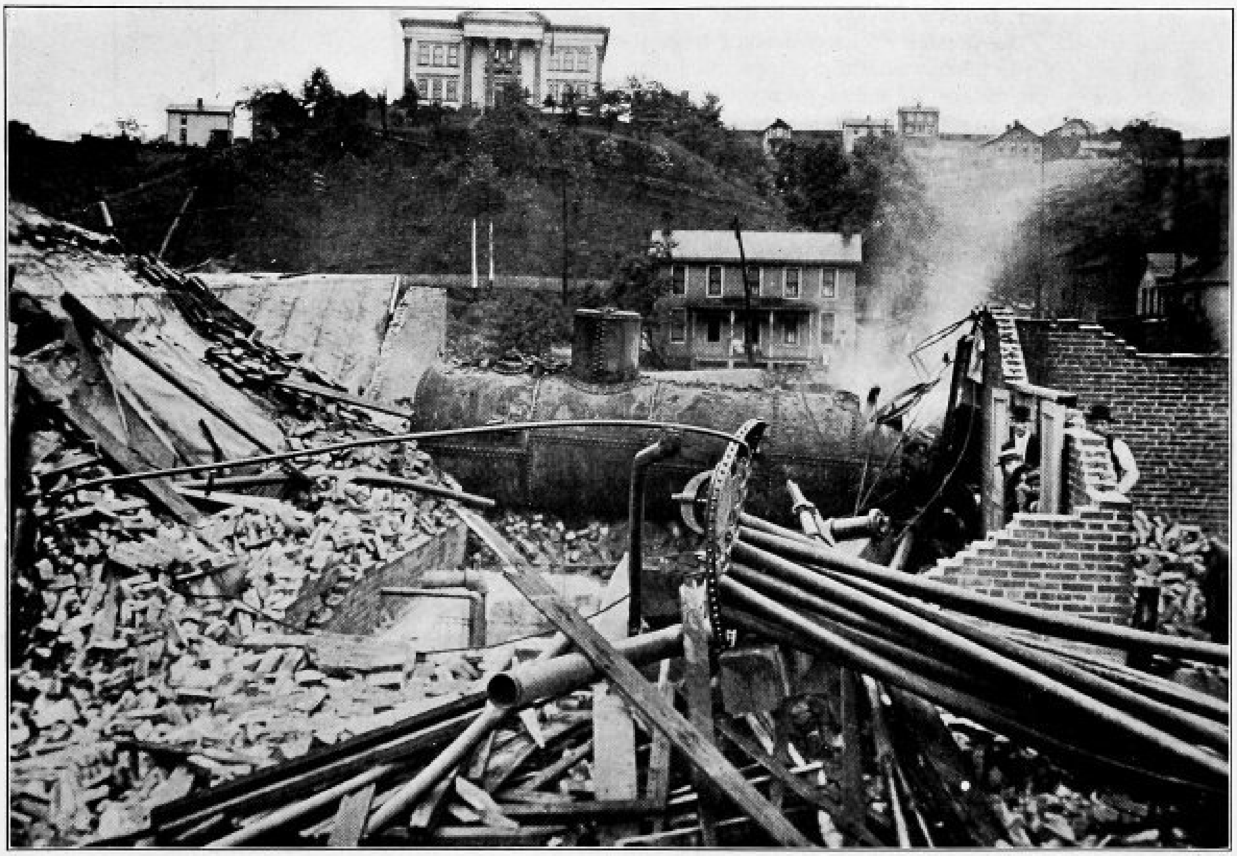
Licensing of engineers is in many communities where such ordinances are in force encumbered with so much red tape that it becomes a mere nuisance. The examination in itself is usually worth little or nothing. The questions asked are nearly always the same, in many cases taken simply from a text-book where the answers are written alongside. What a farce!

Many of the examiners would not if they were called upon to do it know how to start an examination without a book. The engineer himself is, under the present system, receiving no justice. If he takes out a license in Ohio it is no good in Michigan, and vice versa. If the constitution allows it, a license law should without fail be under Federal control, so that if an engineer took out a license in one State it would be good in all the other States.

DIFFICULTIES IN WAY OF SECURING LEGISLATION.

I am aware that bills governing boiler inspection have already been introduced in nearly every State, and I am also conversant with the fact that, with the exception of five, they have all died a natural death, for the simple reason our legislative bodies are not sufficiently representative of the diversified interests of the country. The majority of our legislators, State and Federal, are lawyers and machine politicians, and when such a bill is introduced, unless there are good practical men present to champion it, it is sure to be knocked out. Of all laws from the various States relative to this matter the one recently enacted in the State of Massachusetts borders nearest to perfection; it would furnish a very suitable basis for a Federal law. There may be flaws in it. I shall, however, not attempt to criticise it. Taking it as a whole, it is good and a credit to the men who conceived and formulated it and the State that subsequently enacted it a law.

There has during the past year been appointed a commission to investigate causes of mine explosions and to prescribe remedies for same. Do our authorities know that at present the number of people killed through boiler explosions in this country is far greater in proportion to the number employed than in mine explosions? Such is the case. Therefore, there is every reason that it should receive as much attention. Furthermore, it is a much simpler problem to deal with. We know the causes of boiler explosions and we know the remedy; the only thing remaining is to have it administered.



RESULTS OF A RECENT BOILER EXPLOSION AT MONONGAHELA CITY, PA.

BENEFITS TO BE DERIVED BY VARIOUS INTERESTS.

How would such a law affect the different interests? It would protect the now honest boiler manufacturer from his unscrupulous competitor, who at the present time, by using a poorer quality of material and allowing inferior workmanship, can undersell an honest man in the market. Our insurance companies would do a larger and safer business. It has been asked, wouldn't such a law injure the insurance companies, wouldn't a great number of steam users who are now resorting to them for inspection cancel their insurance and have their inspections made by the State? The idea is ridiculous. The integrity of our insurance companies and their efficiency as a medium of inspection have been too thoroughly established in the minds of the American steam user to be suddenly cast overboard, and it is obvious that a department created by such a law would have to be self-supporting. Therefore, the cost of inspection by State or by insurance companies would be practically the same, and as there will always be a possibility of explosions, the majority, on strict business principles, would keep on carrying their insurance, as they now do for fire. The insurance companies would do a safer business, inasmuch as there would be no question of getting the boilers for the prescribed yearly inspections under conditions that would permit the same to be done in a proper manner.

The greatest benefit, however, would be derived by the steam user himself. The greater efficiency derived from always having his plant in perfect condition would more than doubly compensate for the cost of shutting down for inspection and repairs.

This goes to show that it would benefit all. Why not, then, get together for the common interests, draft a bill in such a manner that it discriminates against no one; have it presented to our legislators, and finally have sufficient pressure applied to see that it will be enacted into a law?

As an issue in a national campaign, it might not arouse so much interest as a newly-invented trust-bursting device or anti-injunction plank, but to all thinking men who have studied the present state of affairs it should appear of far more importance. The fact that hundreds of lives that are now annually offered on the altar of negligence could either all or in part be saved should in itself be reason enough for the enactment of such a law.

Strength of Riveted Joints.*

BY J. W. RAUSCH.†

In joining two plates by what is known as the lap joint (see Fig. 1) it will be seen that a certain amount of metal is punched or drilled out in order to receive the rivets. The plate is therefore weakened to the extent that these holes

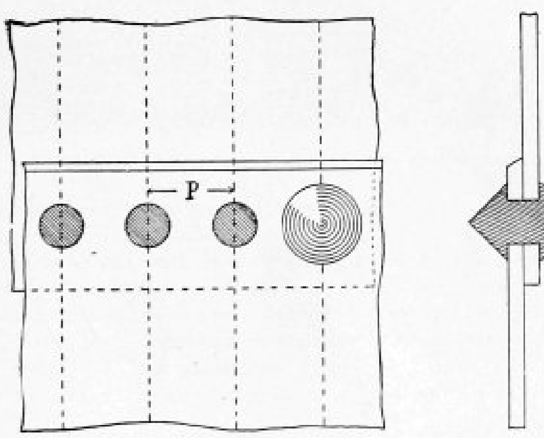


FIG. 1.

bear to the solid sheet. The distance which these holes are apart is called the pitch, and may be represented by the dotted lines. If, therefore, the diameter of the rivet hole equals one-half of the pitch, then the plate is reduced by one-half of its original strength, or 50 percent.

In order to make the above clearer, it will be assumed that the pitch is 2 inches, the rivet hole 1 inch, the thickness of plate ⅜ inch, and the tensile strength of plate 60,000 pounds per square inch of section. The ultimate strength of the section of plate before punching or drilling represented by the pitch (see Fig. 2) will equal width times thickness times tensile strength, or

$$2'' \times \tfrac{3}{8}'' \times 60{,}000 = 45{,}000 \text{ pounds.}$$

Fig. 3 is a section of the plate represented by the pitch after drilling, and the ultimate strength equals:

$1'' \times \tfrac{3}{8}'' \times 60{,}000 = 22{,}500$, or one-half of its original strength.

From the above it will be seen that to find the efficiency of the plate, subtract the diameter of the rivet hole from the

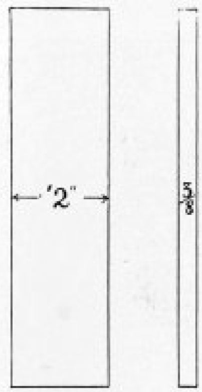


FIG. 2.

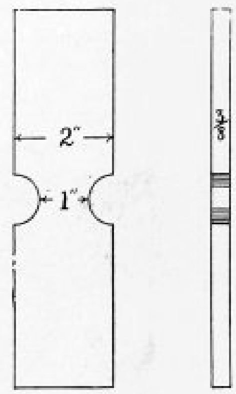


FIG. 3.

pitch and divide the remainder by the pitch. This may be expressed as follows:

$$\text{Efficiency of plate} = \frac{\text{pitch} - \text{diameter of rivet hole}}{\text{pitch}},$$

$$\text{or } E = \frac{P - h}{P}.$$

The ultimate shearing strength of the rivet equals area of rivet times its shearing strength per square inch of section; in computing the shearing strength of the rivet the diameter of the rivet holes is taken. Assuming that a rivet after it has

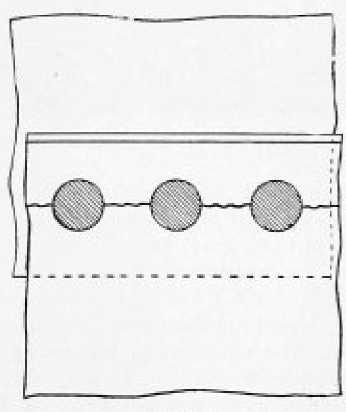


FIG. 4.

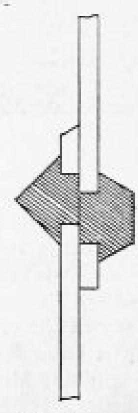


FIG. 5.

been driven is 1 inch in diameter, and the shearing strength of the rivet is 40,000 pounds per square inch of section, then the ultimate strength of this rivet will be the diameter squared, times .7854, times 40,000, or 1 inch × 1 inch × .7854 × 40,000 = 31,416 pounds.

A riveted joint may fail either by the sheet tearing apart, as is shown in Fig. 4, or by the rivets shearing, as shown in Fig. 5, or by the plate in front of the rivet hole being crushed, as shown in Fig. 6, or by shearing out the lap, as shown in Fig. 7.

A study of the sketches will make it clear that if the rivet

* From a lecture delivered at a meeting of Euclid Council, No. 14, Universal Craftsmen Council of Engineers, Baltimore, Md.
† Inspector, Maryland Casualty Company.

is made larger it will gain in area and proportionately in strength, but at the expense of reducing the plate area and a proportionate weakening of the plate. On the other hand, if the rivet is made smaller, the plate area is increased, but at the expense of the rivet area; so that in order to secure the maximum strength the shearing strength of the rivets should equal the tensile strength of the plate between the rivet holes.

PITCH OF A SINGLE-RIVETED SEAM.

To find the correct pitch or distance which the rivets must be apart, so that the shearing strength of the rivets will equal the tensile strength of the plate, multiply the area of the rivet hole by the shearing strength of the rivet, and divide this product by the thickness of plate times its tensile strength, and to this quotient add the diameter of the rivet hole. This may be expressed as follows:

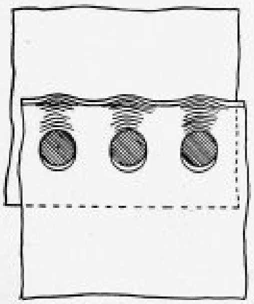


FIG. 6.

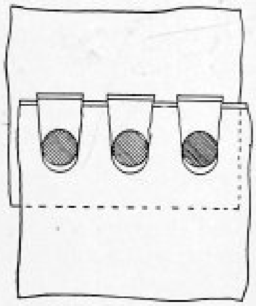


FIG. 7.

$$\text{Pitch equals } \frac{\text{area} \times \text{shearing strength of rivet}}{\text{thickness of plate} \times \text{tensile strength}} + \text{rivet hole.}$$

$$\text{Or } P = \frac{AS}{tT} + h.$$

Example: What is the correct pitch of rivets if the plate is 3/8 inch thick and of 60,000 pounds tensile strength, the rivets 7/8 inch and rivet holes 15/16 inch; shearing strength of rivet 40,000 pounds?

$$\text{Area of rivet} = 15/16 \times 15/16 \times .7854 = .6903.$$

$$\text{Pitch} = \frac{.6903 \times 40{,}000}{3/8 \times 60{,}000} + 15/16 = 2\,3/16 \text{ nearly.}$$

Or

```
.6903
 40000
_______
27612.0000 strength of rivet: 3/8" × 60,000 = 22500.
22500)27612.0000(1.2272, or 1.23 —, or 1¼ nearly.
      22500
      _____
       51120
       45000
       _____
        61200
        45000
        _____
        162000
        157500
        ______
          45000
          45000        1¼ + 15/16 = 2 3/16" pitch.
          _____
```

It will be noticed that 27612 ÷ 22500 = 1.23. This is only two one hundredths less than ¼, so that in practice 1¼ would be taken, and by adding 15/16 inch, the diameter of the rivet hole, we have 2 3/16 inch as the pitch; but in practice it is well to space the rivets in a single-riveted lap joint a little farther apart, because in constructing the seam everything tends to make the rivet larger and reduce the plate area. For instance, if the plate is punched, the punch for a 7/8-inch rivet would be 15/16, and the die would be 1 inch, so that the hole in the plate would be tapered, that is to say, it would be 15/16 inch on one side and 1 inch on the other; also reaming is very often necessary, which increases the rivet area at the expense of the plate area.

The ultimate strength of a seam will depend upon its weakest part, the same as the strength of a chain will depend upon its weakest link; so that the efficiency of the seam will depend upon the strength of its weakest part as compared to the solid sheet. From this it will be seen that to find the efficiency we must first find the efficiency of the plate; second, the efficiency of the rivets, and third, the resistance to crushing as compared to the solid plate, and the weakest of the three should be taken.

CRUSHING.

It has been found by experiment that the crushing strength in front of the rivets is high and irregular, and according to the best authorities, in some of the tests the crushing strength was as high as 150,000 pounds per square inch of section, while in a few tests it was less than 85,000 pounds; so that 90,000 pounds will probably be safe in calculating riveted joints. The usual method adopted in calculating the crushing strength is to multiply the diameter of the rivet hole by the thickness of the plate, then multiply this product by the crushing strength.

LAP.

In practice a sufficient lap can always be made so that a joint never fails by shearing out, as shown in Fig. 7. The distance from the center of the rivet to the edge of the lap

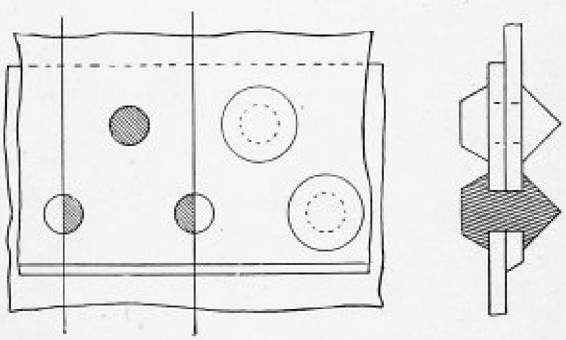


FIG. 8.

is usually one and a half times the diameter of the rivet hole. This appears to give an ample margin of safety and is also satisfactory for calking.

Example: What is the efficiency of a single-riveted lap joint of the following dimensions?

Shell plates, 3/8 inch thick.

Strength of plates 60,000 pounds per square inch of section.

Rivets, 7/8 inch.

Shearing strength of rivets, 40,000 pounds per square inch of section.

Rivet holes, 15/16 inch.

Pitch of rivets, 2 3/16 inches.

Crushing strength 90,000 pounds per square inch of section.

In a former example we found that the efficiency of plate equals

$$\frac{P - h}{P}, \text{ or } \frac{2\,3/16 - 15/16}{2\,3/16} = \frac{35/16 - 15/16}{35/16} =$$

$$\frac{20/16}{35/16} = 20/16 \times 16/35 = 20/35 = .57$$

Or 57 percent for the plate.

To find the efficiency of rivets, multiply the area of the rivet hole by the shearing strength of the rivet and divide this product by the pitch times the thickness of plate times the tensile strength of plate.

This may be expressed as follows:

$$\text{Efficiency equals } \frac{\text{area} \times \text{shearing strength of rivet}}{\text{pitch} \times \text{thickness of plate} \times \text{tensile strength}}$$

$$\text{Or } \frac{.6903 \times 40{,}000}{2\ 3/16 \times 3/8 \times 60{,}000} = \frac{27612}{49218.75} = .56$$

Or 56 percent for the rivets.

The resistance to crushing as compared to the solid sheet equals

$$\frac{h\,t\,C}{P\,t\,T} = \frac{\text{diameter of rivet hole} \times \text{thickness of plate} \times \text{crushing strength}}{\text{pitch} \times \text{thickness of plate} \times \text{tensile strength}}$$

$$= \frac{15/16 \times 3/8 \times 90000}{2\ 3/16 \times 3/8 \times 60000} = \frac{31640.625}{49218.75} = 64 \text{ percent.}$$

It will be noticed that the resistance to crushing is in excess of the strength of the plate and the rivets. It will also be noticed that the efficiency of the rivets is 1 percent less than the efficiency of the plate. Also, in referring to the calculation wherein the correct pitch was determined, it will be found that the pitch should have been 2/100 of an inch less than 2 3/16 inches, which accounts for the difference of the 1 percent.

Double and Triple Riveted Lap Joints.

A lap-riveted joint may be made stronger if instead of using one row of rivets two or more rows are used.

Fig. 8 represents what is known as the double-staggered riveted lap joint. In comparing this joint with the single-

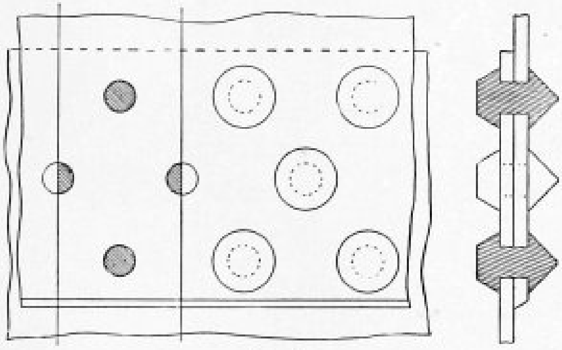


FIG. 9.

riveted joint it will be noticed that instead of there being one rivet in each pitch there are two, making the shearing strength of the rivets in each pitch proportionately stronger. In this way the pitch may be increased, thus gaining a greater efficiency. There is, however, a limit to the spacing of the rivets, for the reason that if the rivets were spaced too far apart the lap of the seam could not be kept tight.

Fig. 9 shows the construction of a triple-riveted lap joint. In this construction the joint may be made stronger by increasing the pitch, or by using smaller rivets. The shearing strength of the rivets is taken care of by the additional rivet in each pitch. In computing the strength, or in determining the correct pitch of a double or triple-riveted lap joint, the same principle applies as for the single-riveted joint; that is to say, the method is exactly the same, only the number of rows of rivets must be taken into consideration.

To find the correct pitch of a double or triple-riveted lap joint so that the shearing strength of the rivets will equal the tensile strength of the plate, multiply the area of the rivet hole by the number of rows of rivets, then multiply this product by the shearing strength of the rivets, and divide the result of the thickness of the plate times its tensile strength, and to this quotient add the diameter of the rivet hole. This may be expressed as follows:

$$P = \frac{A\,N\,S}{t\,T} + h$$

P = Pitch of rivets.
h = Diameter of rivet hole.
A = Area of rivet hole.
N = Number of rows of rivets.
S = Shearing strength of rivets.
t = Thickness of plate.
T = Tensile strength of plate.

Example: What is the correct pitch of the rivets of a double-riveted lap joint, where the plate is of steel 3/8 inch thick and of 55,000 pounds tensile strength, rivets 7/8 inch in diameter of 40,000 pounds shearing strength, rivet holes 15/16 inch in diameter?

According to the foregoing formula

$$\text{Pitch} = \frac{.6903 \times 2 \times 40{,}000}{3/8 \times 55{,}000} + 15/16 = 3.615$$

3/8 = .375   area of 15/16 = .6903
55000   2
1875000   1.3806
1875   40000
20625.000   20625)55224.0000(2.6775
diameter 15/16 = .9375   41250
2.6775
3.6150   139740
123750
159900
144375
155250
144375
108750
103125
5625

It will be seen that theoretically the correct pitch, so far as it relates to the shearing strength of the rivets and the tensile strength of the plate, is 3.615 inches, but in practice this pitch would, in all probability, be too great to insure a tight joint.

The correctness of the foregoing example may be proven by calculating the efficiency of the plate and the rivets.

To find the efficiency of the plate of a double or triple-riveted lap joint, subtract the diameter of the rivet hole from the pitch and divide the remainder by the pitch.

To find the efficiency of the rivets of a double or triple-riveted joint, multiply the area of the rivet hole by the number of rows of rivets, and multiply this product by the shearing strength of the rivets; then divide this result by the pitch times the thickness of plate times the tensile strength of the plate

According to the foregoing example, we have the following:

Efficiency of plate =

$$\frac{P-h}{P}=\frac{3.615-.9375}{3.615}=\frac{2.6775}{3.615}=74 \text{ percent.}$$

Efficiency of rivets =

$$\frac{A\,N\,S}{P\,t\,T}=\frac{.6903\times2\times40{,}000}{3.615\times.375\times55{,}000}=\frac{55224}{74559.375}=74 \text{ percent.}$$

The resistance to crushing is usually in excess of the strength of the plate and rivets, and in this case the efficiency as to crushing equals

$$\frac{2\,h\,t\,C}{P\,t\,T}=\frac{2\times.9375\times.375\times90{,}000}{3.615\times.375\times55{,}000}=84 \text{ percent.}$$

Butt Joints.

DOUBLE-RIVETED BUTT JOINTS.

Fig. 10 illustrates the construction of a double-riveted butt joint. There are two rows of rivets on each side of the joint. The rivets in the two inner rows are in double shear, and the rivets in the outer rows are in single shear. There are three rivets in each pitch; one in the outer row, which is in single shear, and two in the inner row, which are in double shear. If this joint were to fail by the rivets shearing, then the rivets in the inner row would have to shear in two places; so that for each pitch five sections of rivets would have to be sheared. In practice it is not customary to allow twice the shearing resistance for rivets in double shear. Usually 1.75 times single shear is allowed for double shear.

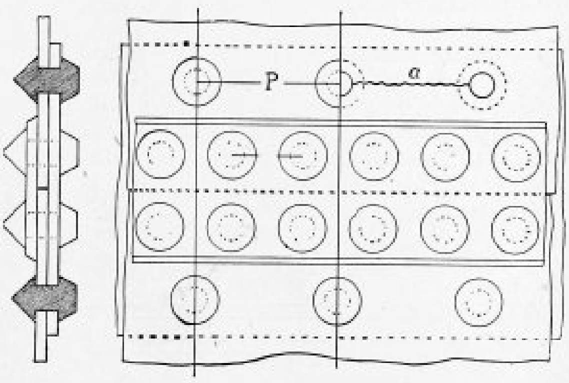


FIG. 10.

There are five ways in which this joint may fail, and to determine the efficiency the strength of each part may be calculated separately, and then the strength of the weakest part divided by the strength of the solid plate.

Example: What is the efficiency of a double-riveted butt joint of the following dimensions?

Thickness of plate, 7/16 inch.
Thickness of covering plates, 7/16 inch.
Diameter of rivets, ⅞ inch.
Diameter of rivet holes, 15/16 inch.
Pitch of outer row of rivets, 5¼ inches.
Pitch of inner row of rivets, 2⅝ inches.
Tensile strength of plate, 55,000 pounds.
Shearing strength of rivets (mild steel), 45,000 pounds.
Crushing strength, 90,000 pounds.

Calculating the resistance of each part separately the joint may fail.

First, at the outer row of rivets. The resistance is

$(P-h)\,t\,T=(5¼-15/16)\times7/16\times55{,}000=103{,}769.$

Second, by tearing apart at the inner row of rivets and shearing one of the rivets in the outer row. The resistance is

$(P-2\,h)\,t\,T+A\,S=(5¼-2\times15/16)\times7/16\times55{,}000+.6903\times45{,}000=112{,}274.$

Third, by shearing two rivets in double shear and one rivet in single shear. Allowing 1.75 times single shear for double shear, the resistance is

$2\,A\,S\,1.75+A\,S=2\times.6903\times45{,}000\times1.75+.6903\times45{,}000=139{,}785.$

Fourth, by crushing in front of two rivets and shearing one rivet. The resistance is

$2\,h\,t\,C+A\,S=2\times15/16\times7/16\times90{,}000+.6903\times45{,}000=104{,}891.$

Fifth, by crushing in front of three rivets. The resistance is

$3\,h\,t\,C=3\times15/16\times7/16\times90{,}000=110{,}742.$

The resistance of a piece of plate equal to the width of the pitch at the outer row of rivets equals

$5¼\,t\,T=5¼\times7/16\times55{,}000=126{,}328.$

The least resistance being at the outer row of rivets (see *a*, Fig. 10) the efficiency equals

$$\frac{103{,}769}{126{,}328}=82 \text{ percent.}$$

TRIPLE-RIVETED BUTT JOINTS.

Fig. 11 illustrates the construction of a triple-riveted butt joint. There are three rows of rivets in each side of the joint. The rivets in the two inner rows are in double shear, and the rivets in the outer row are in single shear. There are five rivets in each pitch; four of them are in the inner row, and are in double shear, and one is in the outer row and is in single shear. So that if this joint were to fail by the rivets shearing, nine sections of rivets in each pitch would have to be sheared.

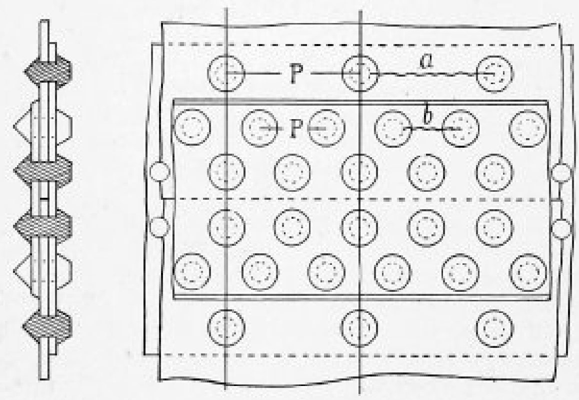


FIG. 11.

Example: What is the efficiency of a triple-riveted butt joint of the following dimensions?

Thickness of plate, 7/16 inch = *t*.
Thickness of covering plates, ⅜ inch = *t'*.
Diameter of rivets, ⅞ inch.
Diameter of rivet holes, 15/16 inch.
Pitch of outer row of rivets, 6¾ inches.
Pitch of inner row of rivets, 3⅜ inches.
Tensile strength of plate, 55,000 pounds.
Shearing strength of rivets (iron), 38,000 pounds.
Crushing strength, 90,000 pounds.

There are five ways in which this joint may fail. Calculating the resistance of each part separately, the joint may fail.

First, at the outer row of rivets. The resistance is

$(P-h)\,t\,T=(6¾-15/16)\times7/16\times55{,}000=139{,}863.$

Second, by tearing apart at the middle row of rivets (see *b*, Fig. 11) and shearing one rivet in the outer row. The resistance is

$(P-2\,h)\,t\,T+A\,S=(6¾-2\times15/16)\times7/16\times55{,}000+.6903\times38{,}000=143{,}536.$

Third, by shearing four rivets in double shear and one rivet in single shear, allowing 1.75 times single shear for double shear. The resistance is

$$4\,A\,S\,1.75 + A\,S = 4 \times .6903 \times 38{,}000 \times 1.75 + .6903 \times 38{,}000 = 209{,}851.$$

Fourth, by crushing in front of four rivets and shearing one rivet. The resistance is

$$4\,h\,t\,C + A\,S = 4 \times 15/16 \times 7/16 \times 90{,}000 + .6903 \times 38{,}000 = 173{,}887.$$

Fifth, by crushing five rivets. As the covering plates are thinner than the shell plate, and as one of these rivets passes through one of the covering plates only, the crushing resistance of one rivet must be taken at the thinner plate. The resistance is

$$4\,h\,t\,C + h\,t'\,C = 4 \times 15/16 \times 7/16 \times 90{,}000 + 15/16 \times 3/8 \times 90{,}000 = 179{,}297$$

The resistance of a piece of plate equal to the width of the pitch at the outer row of rivets equals

$$6\tfrac{3}{4}\,t\,T = 6\tfrac{3}{4} \times 7/16 \times 55{,}000 = 162{,}422.$$

The least resistance being the outer row of rivets (see *a*, Fig. 11) the efficiency equals

$$\frac{139{,}863}{162{,}422} = 86 \text{ percent.}$$

Flanging Boiler Plates.—VI.

BY JAMES CROMBIE.

Heavy Flange Press Work.

In flanging on the press it is not necessary that the fillet in the bottom of the female die should conform to the radius or shape of the male die, as the plate when passing through the female die will take the shape of the male die or former. It will thus be readily understood that a female die of the required shape, yet without a bottom in it, will flange the plate, but would not leave the face in a very desirable condition, especially where that surface must be flat, as in a head for a boiler. In practice a false bottom is employed. This

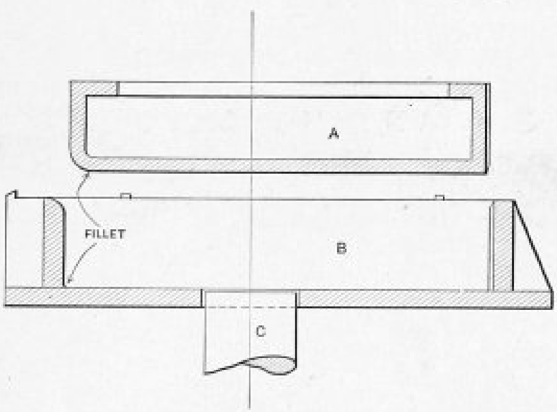


FIG. 62.—DIES FOR FLANGING HEAD OF LOCOMOTIVE-TYPE BOILER.

bottom is usually on the internal ram, and clamps or holds the sheet up against the male die. The female die then ascends and forces the flange up against the male die, and the sheet is thus kept flat on the face and leaves the dies in a nicely finished condition.

When a die is made specially for one size of sheet, and a large number of sheets are required, it will be the better plan to have a bottom cast in the female die, leaving only a small hole in the center the size of the internal ram, the ram to form part of the bottom of the die while flanging, and then to act as an ejector after the plate is flanged.

Take, for instance, the front head of a locomotive-type boiler, such as is largely used for sawmill work, the plate is 68 by 50 inches. The dies for flanging this plate are shown in Fig. 62. *A* is the male die, *B* is the female die. This die has a bottom in it with a hole in the center large enough to allow the ram *C* to pass through easily. There are guide pieces at the end and sides of the female die to bring the hot plate into position at once. In operating, the male die *A* is

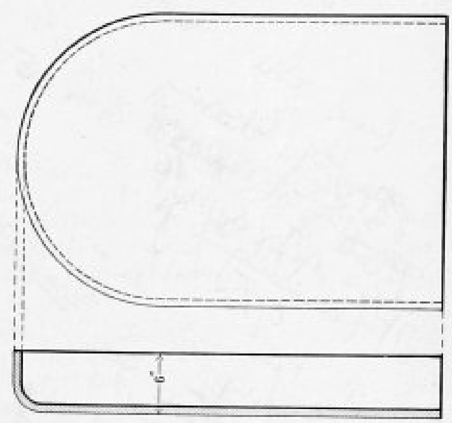


FIG. 63.—HEAD OF LOCOMOTIVE-TYPE BOILER AFTER FLANGING.

bolted to the top table of the press. The female die *B* is bolted to the moving platen, the hot plate is placed in position on the female die, and pressure applied to the main platen, which, ascending quickly, flanges the plate, as shown in Fig. 63. It will be observed that at the straight end of the dies there are chafing or fitting strips. These strips are to keep the dies a tight working fit lengthwise. The gather is all at one end of the plate; that is, around the circular portion. If the dies were not kept a tight fit, the plate would not have

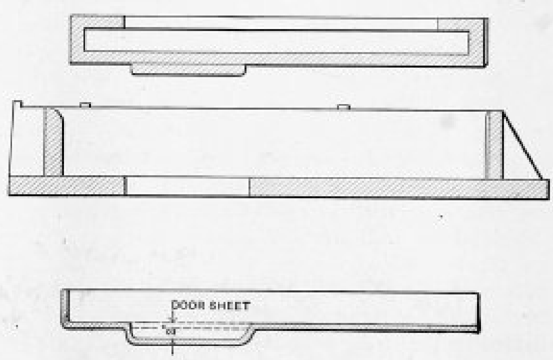


FIG. 64.—DIES FOR FLANGING DOOR SHEET.

a smooth flange and would be humpy. The two straight sides should be an easy fit, and the sheet will not cling to the male die, but will drop off and remain in the female die as it descends. The internal ram *C* can then be used to raise the finished sheet clear of the female die, so that the squad can slide it off and lay it aside. The door sheet for this boiler is also flanged in a somewhat similar manner, the flange being turned up and the recess formed for the fire-hole door at one stroke. Fig. 64 illustrates the male and female dies for the door sheet.

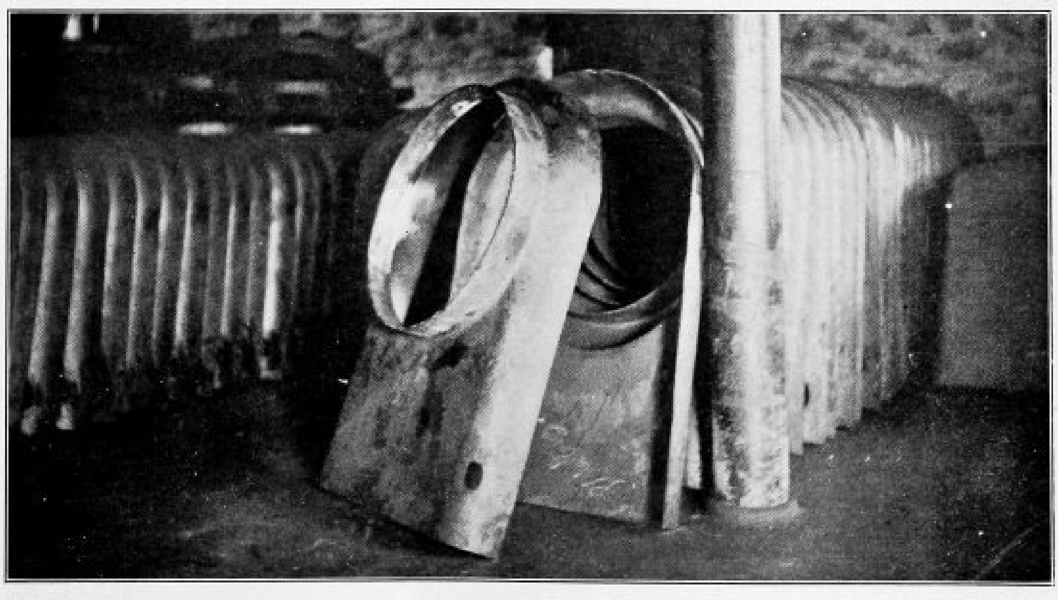
Flanging throat sheets for locomotive-type boilers is a very interesting yet simple operation. They are flanged on each side to take the wagon top, and have also a circular piece flanged outwards to take the girth seam of the barrel of the boiler. These sheets are usually flanged in pairs. A plate the size of the two throat sheets, having a hole cut out in the center, is heated, and the straight flange on either side flanged down at one stroke; a sectional die slightly elliptical

ILLUSTRATING THE VARIOUS SHEETS WHICH REQUIRE FLANGING IN A LOCOMOTIVE-TYPE BOILER.

in shape, which has been previously affixed to the central ram, is then raised, and forms the circular flange on the sheet at one stroke, thus forming two throat sheets, which have only to be cut apart.

The female die is usually cast in quarter sections and bolted together. This enables one to pack the dies to accommodate thicker plates. To prevent the plate pulling down at its weak part when flanging out the circular flange, a hole should be drilled with a downward inclination at either side of the female die, and a sharp-pointed set screw screwed in until it projects through the side of the die. The hot plate will hold fast on this and will not pull up when flanging the center hole. The set screws should be an easy working fit; a turn with a wrench will release the plate, the mark of the set screw will be punched out when punching the plates apart. If the press is not large enough to accommodate dies large enough for two throat sheets, the throat sheets may be flanged singly at one stroke of the ram. They will pull down from ½ inch to ¾ inch, but this will not matter much, as these corners have to be scarfed or drawn out to go between the wagon top and the circular part of the boiler, or the plate may be ordered from the mill 1 inch wider at this end. This will give a straight back when trimmed after flanging. There is another way to overcome this pulling down of the plate, and that is by heating in the fire the flange for the girth seam, and leaving the two sides cold; this will flange nicely, forming all three flanges at one operation, and leaving the back perfectly straight. Fig. 65 shows this sheet and Fig. 66 the dies for flanging it. With a slight change in the male die these formers may also be used in the sectional flanger.

To flange this sheet the male die *A* is fixed to the top of press, and the female die *B* to the main platen. The hot sheet



FLANGED THROAT SHEETS OF LOCOMOTIVE-TYPE BOILER.

is then placed in position on the female die. If the sheet has been heated all over in the furnace, the wings at *a* (Fig. 65) should be given a few blows with a sledge hammer. As soon as the pressure is applied this part will turn down against the side of the dies and will catch on a suitable stop just before

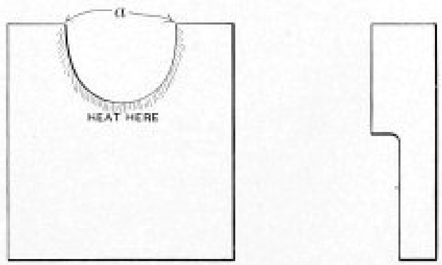


Fig.65

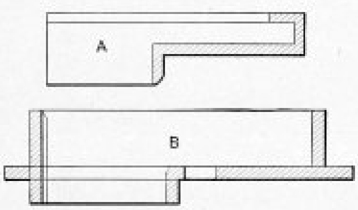


FIG. 66.

the dies come to rest on completion of the squeeze, or forming operation, and so prevent, as far as possible, the pulling down. If the plate is heated in the fire, as per Fig. 65, it will not be necessary to hammer it or provide a stop. The sheet after flanging will remain in the female die, from which it can be raised by the internal ram.

Another style of throat sheet that is used extensively is shown in the photograph. It takes the wagon top all round and also the barrel of boiler, and is for double riveted joints. The flanging of this plate is a very interesting opera-

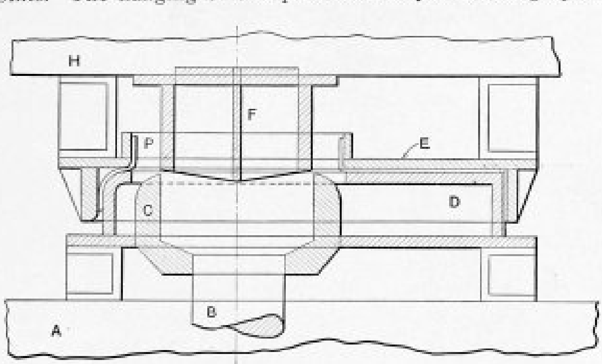


FIG. 67.—DIES FOR FLANGING THROAT SHEETS.

tion, as it is punched out and both flanges formed in one heat.

The dies as designed by the writer are illustrated at Fig. 67. In flanging the plate the dies will form the outer flange first, so that there will be no danger of tearing the sheet out of shape across the weak part of the center of the hole. Then after forming the outer flange the hole is punched out and the circular flange formed, all operations taking place in one heat; or the hole may be punched first, and then both flanges formed simultaneously.

In Fig. 68 *A* is the main platen, *B* the central ram, to which is affixed the male former *C*, which forms the circular flange and also acts as a die in connection with the punch *F* to punch out the hole in the plate. *H* is the top of the press to which the punch *F* is bolted. *E* is the female former for both flanges, and it is suitably suspended from the top of press and is central with the punch and die. *D* is the male former for the outer flange. These dies are all in position for flanging.

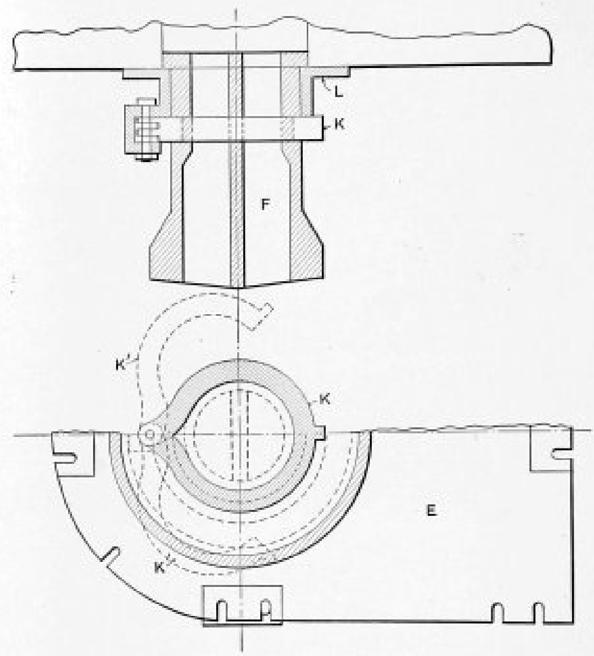


FIG. 68.—PUNCH USED IN FLANGING THROAT SHEETS

The plate is heated in the furnace and laid in position on the die *D*. Pressure is applied to the main platen *A*, which raises the die *D* with the sheet and forms the outer flange. When the die comes to within about 1 inch of the female die *E*, the pressure is applied to the ram *B*, which ascends, with the die *C*, and punches the hole. The die *D* now acts as a clamping die, and the die *C*, still ascending, forms the circular flange. Fig. 67 shows the dies after the flanging is completed. The flanged sheet is still in position at *P*, and the die *D* is holding the sheet while the die *C* returns, when die *D* can be relieved, bringing the sheet with it, from which it can be quickly lifted off before contracting.

In Fig. 68 is shown another style of punch that may be used in connection with these dies. *F* is the punch. This punch is machined to work in the flange *L*. The punch has also a groove or recess into which the gag *K* fits. This gag is in two pieces, and is hinged, as shown in the plan and elevation.

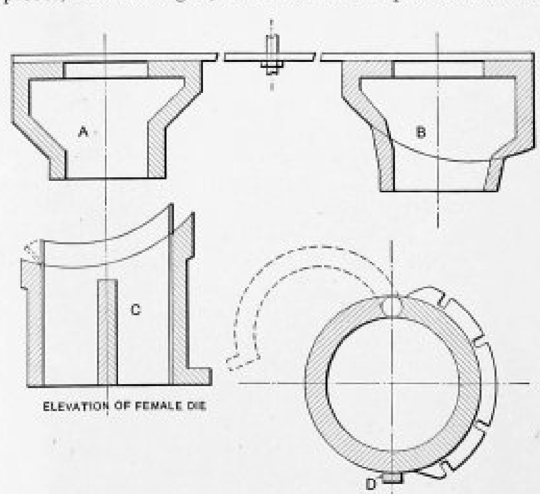


FIG. 69.—DIES FOR FLANGING AN OFFSET DOME SHELL.

The sheet is laid in place as previously described, and the hole is first punched; the gag is then thrown open as at K', allowing the punch to slide up inside the hole in the top table; both rams, rising at the same time, engage both flanges and form them simultaneously. On lowering the flanged head the punch will follow, when the gag can be thrown into place, ready for the next plate; or, as in the previous case, the punch can be kept up out of the way and the outer flange formed, the dies lowered until the gag engages the punch, when the plate may be punched and flanged, all operations being done in one heat. If the press has a ram on top the punch can be fixed direct to the ram, simplifying matters very much. The finished hole in this case is 30 inches diameter. The plate is

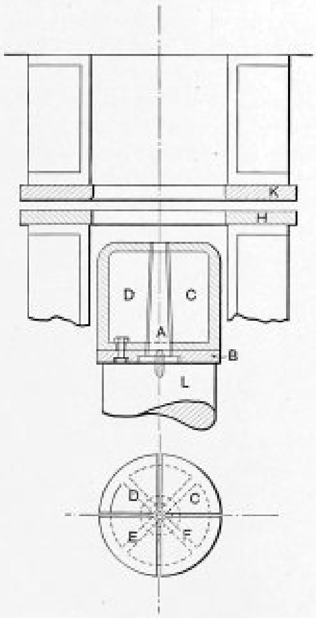


FIG. 70.

¼ inch and 5/16 inch thick. The size of the male former is 30⅛ inches diameter. This has been found in actual practice, covering the flanging of many hundred heads of this size, to be correct for shrinkage.

The writer has gone fully into the flanging of these throat sheets, as it is one of the most difficult plates in boiler work, and these same principles may be applied to any sheet. The inside flue sheet of a small marine boiler is flanged in much the same way, the outer flange for the fire-box and the hole for the main flue being formed at once.

The flanging of the shell of a dome in the hydraulic press is another operation worthy of mention. The dies are shown in Fig. 69. The shell is first laid out and punched and rolled up. In this case the center of the dome is 3 inches off the center of the boiler. *A* and *B* are the male dies. They are attached one at each end of a plate or bar. This plate is suspended from the top of the press by a center bolt, so that the plate can revolve freely. *C* is the female die. It is made in two halves. These are hinged together, so that one-half can be bolted firmly to the main platen and the other half open freely to receive the dome. The shell is heated and placed inside the female die. The die is closed, and a clamp placed on the projecting flange *D* to keep the dies closed. The male die *A* is then pushed inside the dome. This forces the flange outwards. The table is then lowered and the die *B* is swung into place and the pressure again applied, forcing the die *B* down on the partly-formed flange and finishing it. The clamp is then taken off and the die opened, and the finished dome lifted aside.

Where domes are made for boilers of different diameter the female die could be made to take face blocks to suit the required radius, these blocks to be held in place by set screws, so that they could be quickly taken off and another pair substituted.

It is possible to flange the complete dome out of one sheet of steel. The plate must be very heavy, however, owing to the reduction in the thickness of the walls of the dome. The plate will require a nice red heat, not a cherry red heat, for if too hot the plate would only stretch, instead of the body of the plate traveling upwards with the former to form the walls of the dome. Fig. 70 shows the required dies for forming the complete dome. The clamping die *H* and the female former *K* are both cast-iron rings. The male former is a sectional die, *A* is a central cone, and is fixed to the central ram. It has a projecting flange, which fits into the base plate *B*. On the base plate *B* there are four sections, *C, D, E, F*. These are held loosely in place on the base plate by bolts. When the dome is formed the ram *L* descends and pulls the cone with

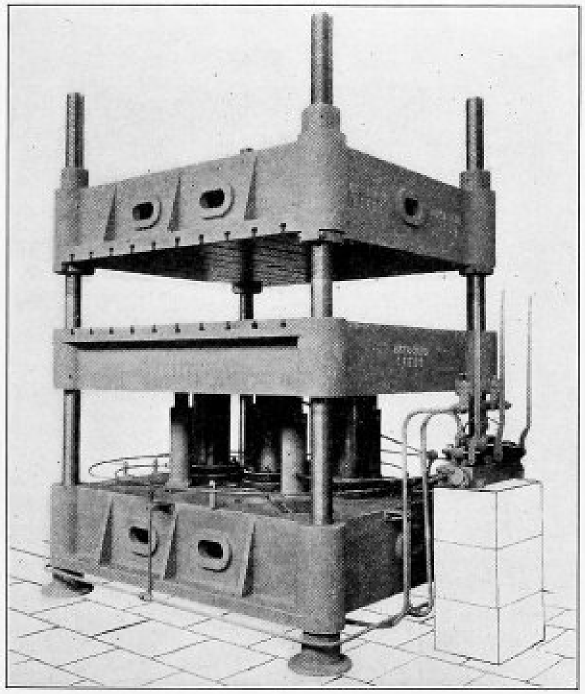


FIG. 71.—FOUR-COLUMN FLANGING PRESS USED IN GREAT BRITAIN.

it. This relieves the four sections, and these follow, leaving the dome on the clamping die. The flange will be flat, and must be set to the radius of the boiler in another die.

A large four-column press, built to flange the largest locomotive head in one heat, is shown in Fig. 71. These presses are built in sizes up to 12 feet between the columns, and have pressures from 350 tons to 1,000 tons. They usually have a 200-ton internal ram and four small clamping rams, also a ram on top.

Sometimes it happens that the plate to be flanged is oversize (in thickness), due to the springing of the rolls at the mill, and when the plate is flanged in the press the dies get stuck and refuse to part; the bottom dies, main platen and central ram are apparently up in the air for keeps, clinging to the top table like some butterfly clinging to a flower instead of behaving like a quiet, hard-working hydraulic flange press. The dies may be forced apart by using the central ram and partly withdrawing the pressure from the main ram; care must be exercised in doing this, because if too much water is withdrawn from the main platen it will drop and jar the supply pipes, and possibly break some of the pipe fittings. Another plan is to slack back the top nut on each of the four columns, then place a piece of 4-inch by 4-inch or other suitable size of lumber at each post, reaching from the main platen up against the lower nuts. Then apply the pressure to the center rams to force them apart; by doing it this way there is less risk of breaking the dies.

Accident to the Boilers of the Brandywine.

In the November issue of The Boiler Maker there appeared drawings of the boilers of the *City of Chester* and the new boilers of the *Brandywine*. Since that article was written the inattention to duty, negligence and misconduct of the assistant engineer caused the crowns of the furnaces to come down, as shown by photograph submitted herewith.

The United States local inspectors for the district of Philadelphia are men thoroughly fitted for their duties by long experience, and their appreciation of the welfare and safety of the traveling public is tending to make engineers realize that in case of accident no mercy will be shown, no friendship considered, and that the standard of work must be raised and upheld. This case was tried, in an impartial and very thorough manner, under Chief Engineer D. H. Howard, inspector of boilers, and Capt. R. A. Sargent, inspector of hulls.

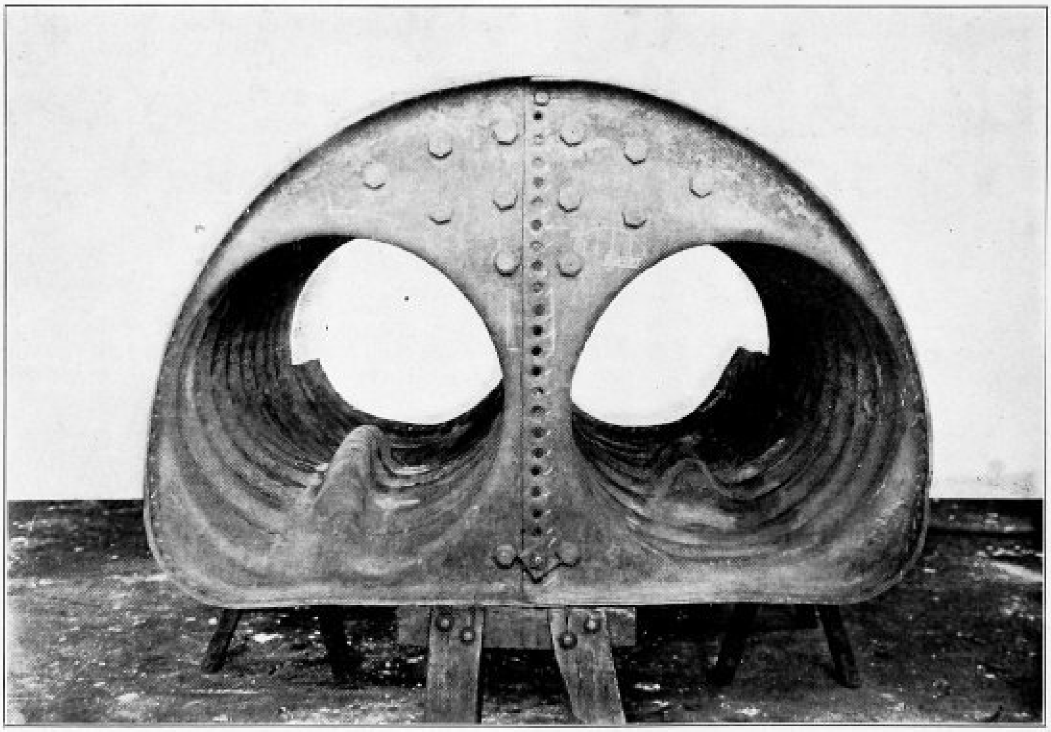
The chief engineer of the *Brandywine* has been on this boat over twenty-two years, and was considered a very careful man, having held a license for over forty years, but it is necesary in the summer season to employ extra engineers, and on the day this accident occurred the regular chief was off duty and the extra man was running chief. The assistant was on watch.

The verdict rendered by the above-mentioned gentlemen, comprising the local board, was as follows:

In the case of the assistant engineer, a licensed engineer of steam vessels, who was tried by the board on Oct. 2, 1908, on the charge of negligence and inattention to duty, it was found that the accused, while acting as engineer of the steamer *Brandywine* on Sept. 5, 1908, through neglect or want of skill, permitted the water in the starboard boiler to become so low as to cause both furnaces to come down and the fusible plug to melt out. The accused was found guilty as charged and his license suspended for a period of ninety days, commencing Oct. 21, 1908.

In the case of the engineer on watch, a licensed engineer of steam vessels, who was tried by the board on Oct. 2, 1908, on charges of negligence and inattention to duty, it was found that the accused, while acting as engineer of the steamer *Brandywine* on Sept. 5, 1908, through neglect or want of skill, permitted the water in the starboard boiler to become so low as to cause both furnaces to come down and the fusible plug to melt out. The accused was found guilty as charged and his license revoked.

In the case of the chief engineer, a licensed engineer of steam vessels, who was tried by the board on Oct. 15, 1908, on charges of negligence, it was found that the machinery on the steamer *Brandywine*, of which he was chief engineer, was in an unsafe condition between the dates of Sept. 1 and Sept. 5, 1908, and that he failed to report the fact to the local inspectors; also that the boilers were used between the dates of Sept. 1 and Sept. 5, 1908, without having proper auxiliary appliances for supplying them with water, and that as a result of his neglect the starboard boiler of the steamer *Brandywine* was on Sept. 5, 1908, damaged to such an extent as to endanger life. The accused was found guilty of all three charges and his license suspended for a period of one year from Oct. 20, 1908.



RESULTS OF LOW WATER IN THE NEW BOILERS OF THE STEAMER BRANDYWINE.

The board was of the opinion that this accident was largely due to gross negligence, misconduct and inattention to duty on the part of the accused, since no deposit of any kind was found in the boiler, it being absolutely clean.

The people can take pride in the verdict as rendered, since it insures proper precautions being taken. The feed pumps were at the shop being overhauled, and hence the injector was depended on. Again, when an examination of the water-glass fittings was made, the bottom was found clogged with mud and the top connection contained pieces of glass which prevented it from functioning. The engineer on watch admitted having renewed the glasses without cleaning out the connections. Taking into account the surface, which was at a high temperature at the time of the accident, if water had been put in boilers, it is probable that the safety valves and engines would not have taken or reduced the volume of steam to a point to prevent rupture. Penalties like this applied where necessary not only tend to elevate the profession but also insure to the traveling public security against accident due to carelessness in the handling of steam machinery. The material of which the furnaces were made was of splendid quality, and showed high physical properties.

CHARLES S. LINCH.

The Slipping Point of Rolled Boiler Tube Joints.*

BY PROF. O. P. HOOD AND PROF. G. L. CHRISTENSEN.

The object of this paper is to supply data regarding the behavior of joints made by the familiar process of rolling boiler tubes into containing holes. Articles dealing with this subject give but little information except as to the ultimate holding power of such joints, and since the joint may be condemned on account of leakage, rather than for lack of maximum holding power, it seems desirable to have information as to the behavior of the joint through its full range of resistance.

When a tube has started from its original seat the fit may be no longer continuous at all points, and a leak may result, although the ultimate holding power of the tube may not be impaired. A small movement of the tube under stress is then the preliminary to a possible leak, and it becomes of interest to know at what stress this slipping begins. A knowledge of the slipping point of a tube in its relation to the ultimate holding power is somewhat analogous to a knowledge of the elastic limit of materials in relation to their ultimate strength, in that working stresses should be kept within the smaller values..

The analogy is further warranted by the appearance of the load-slip diagram from such a joint, which has a general re-

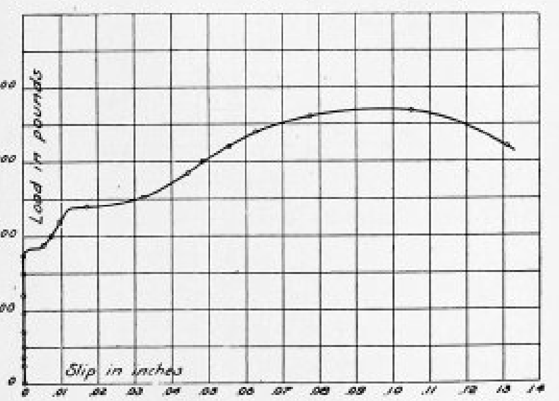


FIG. 1.—TYPICAL LOAD-SLIP DIAGRAM.

semblance to stress-deformation diagrams of tension tests of steel.

Fig. 1 is a typical diagram of the action of a 3-inch, twelve-gage, Shelby cold-drawn tube expanded into a straight machined hole in a 1-inch plate, the tube end projecting ½ inch and not flared. The figures to the left give the total force applied to pull the tube from its seat; the figures below the total slip or movement of the tube through the hole. The curve shows the relation between the load applied and the corresponding slip.

The tube in this joint began to move at 9,000 pounds, and shows a decided slip at 12,000 pounds, reaching an ultimate holding strength of 18,000 pounds.

There is a considerable probability that this joint would leak after the tube had slipped, and be condemned because of its leakiness. This slip occurs at 50 percent of the ultimate holding strength of the joint and at 29 percent of the elastic limit of the material in the tube.

There is then a considerable field for improvement in which to raise the slipping point to a higher percent of the ultimate strength of the joint or of the elastic limit of the tube. The

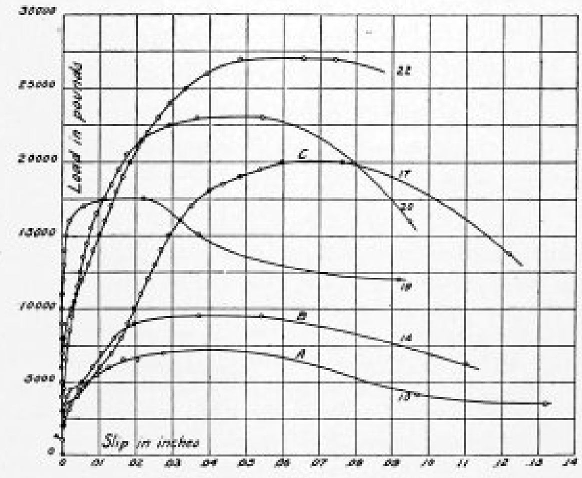


FIG. 2.—3-INCH TUBES ROLLED INTO ½-INCH PLATE.

usual design seems sufficient for most cases, but where high pressures are used or where the stresses due to temperature variations are large, a joint with a higher initial slipping point seems necessary.

In many boiler designs a certain few of the tubes seem to be more highly stressed in service than others, and for such designs a joint of high initial slip would be an advantage. As an illustration, a 3-inch tube under 225 pounds boiler pressure would be urged from its seat by a force of about 1,600 pounds due to pressure alone. In many tests the initial slip comes at about 6,000 pounds. This gives a factor of safety of 3.75 within the slipping point to take care of the unknown temperature stresses. If the design calls on the tube to act as a stay and support the pressure of but 16 square inches this factor of safety within the slipping point is reduced to about 1.7.

In attempting to strengthen the usual joint it might appear that harder rolling of the tube would raise this slipping point, but experiment does not show this. Harder rolling within certain limits will raise the ultimate holding power, but has

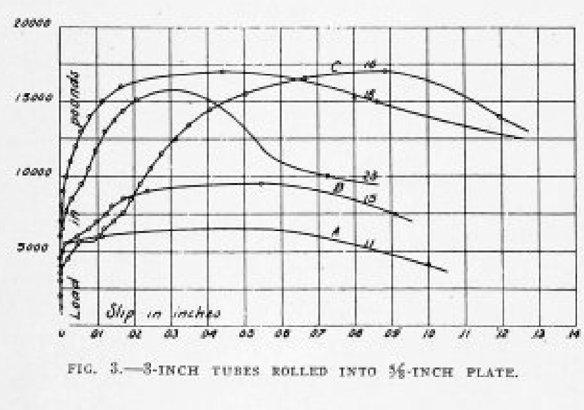


FIG. 3.—3-INCH TUBES ROLLED INTO ⅝-INCH PLATE.

* Presented at the December (1908) meeting of the American Society of Mechanical Engineers.

little effect on the initial slip. This is shown in Figs. 2 and 3, where tubes were rolled into straight machined holes in ½-inch and ⅝-inch plates. In these the tubes *A*, *B*, *C* were rolled respectively light, medium and heavy. Tubes *A* were rolled until the sheet showed a band of loosened mill scale about the

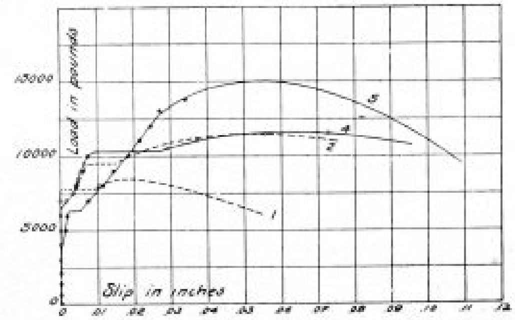


FIG. 4.—LOAD-SLIP DIAGRAMS WITH STRAIGHT AND FLARED TUBE ENDS.

hole 1/16 inch wide, tubes *B*, ⅛ inch wide, and tubes *C*, ¼ inch wide. The general agreement of the slipping points for the several degrees of rolling is noticeable, although the ultimate holding power has been elevated by the harder rolling.

The recommendation to flare the projecting end of the tube has high authority and is of value, but while this raises the ultimate holding power it does not alter the original slipping point. It seems evident that this flared portion would have to be moved into the hole before its metal could come into play, and this initial movement might be the cause of leakage. In Fig. 4 a comparison is made between tubes with straight and flared ends.

The ends of tubes 1 and 2 were not flared, while the ends of tubes 4 and 5 were well flared, and in number 5 the hole was also slightly chamfered. Evidently the point of initial slip has not been greatly influenced by the flaring of the ends, though it is probable that a tube drawn into a hole would be less likely to leak if flared. To discover a more rigid type several forms of tube openings were tested.

If the holes into which the tubes are rolled are tapered

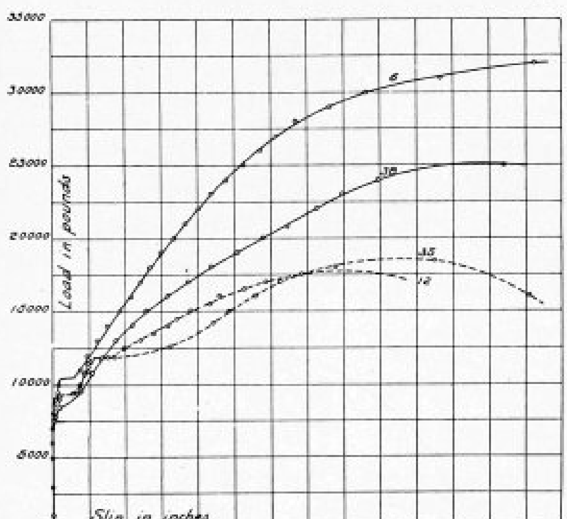


FIG. 5.—DIAGRAMS WITH TUBES WITH STRAIGHT AND TAPERED HOLES.

1/10 inch in diameter per inch in thickness of the plate the first slipping point is hardly affected, but the joint is more rigid after a slip of 1/100 inch and the ultimate strength is increased. In Fig. 5 curves 12 and 35 represent the results from straight holes, while curves 6 and 38 are typical of those having tapered holes. These curves show the slipping points as agreeing in general, but those from tapered holes rise more rapidly, and are thus more rigid.

During the progress of these experiments a form seemed wanted, to put the rolled metal under an initial stress in the direction of the axis of the tube, thus reinforcing the frictional resistance and making movement unnecessary to develop a larger resistance to the first slip. A tapered hole in the sheet

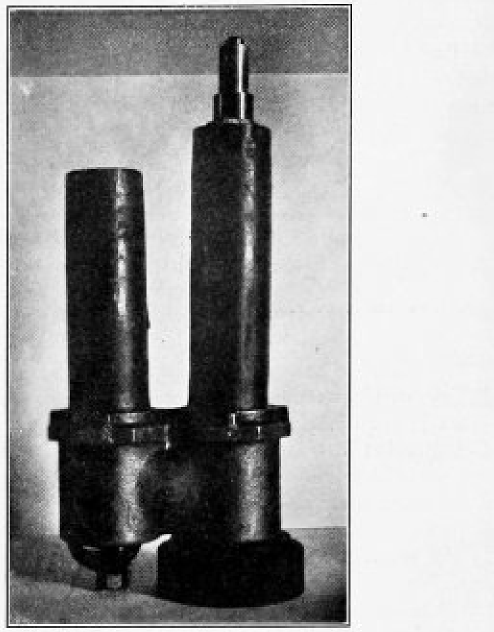


FIG. 6.—TUBES SUBJECTED TO HYDRAULIC PRESSURE.

was therefore given a reverse taper also, so that its smallest diameter was ⅛ inch from the tube side of the sheet.

This amounted to a slight chamfering of the inner side of the tube sheet. Rolling the tube against the two tapers would develop such stresses along the tube as should help to resist movement. In Fig. 11 numbers 36, 44, 26, 25, 38 and 37 had double taper. Compared with the straight holes, the general effect was to lower the slipping point somewhat, but increase the rigidity. Two such tubes were tested by fluid pressure,

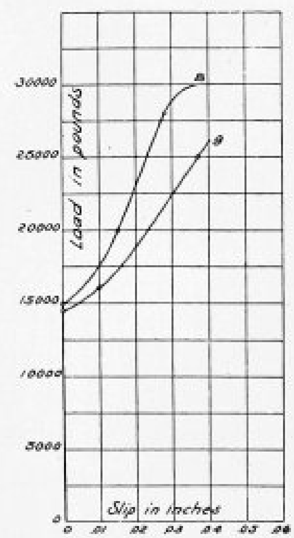


FIG. 7.—3-INCH TUBES ARRANGED AS IN FIG. 6.

the tubes having 1-inch bearing in malleable boxes of the form used in the Parker boiler. The combination of tubes, with closed ends, and the box were filled with oil, and an accurately-ground plunger forced in under the testing machine, as shown in Fig. 6. The results are shown in Fig. 7 as No. 9.

No. 8 was a tube in a similar box forced out by direct loading in the machine. The minute movement of the tubes in both tests was less easily measured in this arrangement, but the eye could detect no movement of a fine scratch line at 15,000 pounds load. This corresponds to 2,100 pounds per square inch hydraulic pressure in the box, and the resistance at 1/100 inch slip was sufficient for the purposes of these experiments; this form was therefore adopted for a boiler of the Parker type designed for 300 pounds steam pressure with the feeling that the joint had as high a factor of safety within the slipping point of the tube as had the rest of the boiler within the ultimate strength. Subsequent tests have shown better ways of making still stronger forms.

Form of Joint	Taper per inch	Test No.	Load in pounds at point of Initial Slip	Load in pounds at point of Slip = 1/100 inch	Load in pounds at point of Ultimate Load	Slip in inches at point of Ult. Load
Tube Sheet 1" thick						
Straight and Tapered	.06	1	7800	8000	8400	.02
		2	7800	9500	11400	.05
		7			17200	.12
Flared, Straight and Tapered	.06	4	6000	10300	11500	.07
Flared, Chamfered, Straight and Tapered	.06	5	4000	7600	15000	.06
Tapered and Straight	.06	3	7000	7800	26000	.112
Double Taper	.10	8	16000	17500	30000	.04
		9	14500	15500	21000	
Tube Sheet 5/8" thick						
Straight		11	5000	6100	6400	.03
		15	4500	7000	9500	.04
		16	3700	5900	17000	.088
Punched		18	8000	14700	17000	.044
Double Taper	.10	23	6600	12000	16000	.04
Tube Sheet 1/2" thick						
Straight		10	2000	5600	7400	.03
		14	2000	6800	9500	.035
		17	3000	6000	20000	.06
Punched		19	10000	17200	17500	.022
		20	3500	17000	23000	.036
Double Taper	.10	22	7000	15000	27000	.048
Tube Sheet 3/8" thick						
Straight		13	1300	7000	18000	.045
Punched		21	8000	15200	16500	.027

FIG. 8.—RESULTS OF TESTS ON 3-INCH, 12-GAGE COLD-DRAWN TUBES.

A study of the several tests made shows that in the usual machined joint the resistance to the first slipping comes from friction only. The friction is dependent on the normal pressure of the expanded tube against the sheet, and this will be a maximum when the rolled metal of the tube is stressed to its elastic limit. The rolling of the metal elevates the elastic limit, but it takes a small amount of rolling to reach this maximum value. Further rolling reduces the thickness of the metal in play as fast as the elastic limit is exalted.

Assuming the elastic limit of the rolled metal at from 30,000 to 40,000 pounds, the observed slipping point shows that the coefficient of friction must have been 35 to 26 percent. The total friction per square inch of tube-bearing area seems to be about 750 pounds in tube plates 5/8 and 1 inch thick. It was observed that in straight and tapered holes wherever a high final strength was attained the metal of the tube was in some way abraded. Sometimes the sharp edge of the tube plate would shear a small ring from the metal of the tube, and in other cases patches of the metal had apparently seized and sheared. Computing the probable frictional resistance of these joints and adding the resistance of the sheared area shown on the tube gave a result agreeing closely with the observed ultimate strength of the joint as tested.

Most of these joints also showed a relatively high slipping point, suggesting the necessity of providing shearing resistance in addition to frictional resistance, in order to obtain a high resistance to initial slip. Several forms were therefore made which provided square shoulders in the tube sheet for the tube to be rolled against, with the object of making these several edges abrade the tube when it started to move. This serrating of the holes amounts to but little more than a "rough cut" in machining. Figs. 8 and 9 give the significant results obtained in several series of tests, and Fig. 10 shows the same graphically. Fig. 11 shows the behavior of the tubes of each type up to a slight slip, thus showing the raising of the slipping point by the several methods.

Form of Joint	Serrations: Number per inch	Serrations: Depth in inches	Test No	Load in pounds at point of Initial Slip	Load in pounds at point of Slip = 1/100 inch	Load in pounds at point of Ultimate Load	Slip in inches at point of Ult. Load
Tube Sheet 1" thick							
Straight Machined Hole			12	7000	11500	17700	.085
			24	6000	7000	20000	.12
			27	9000	9500	21000	.10
			32	6400	6000	6400	–
			34	6800	10500	11500	.085
			35	8800	11200	18400	.105
Average				7333	9283	15883	.089
Double Taper (Taper 1/16" in diam. per inch)			25	3500	14000	23000	.08
			26	5500	12800	19700	.047
			36	8200	12600	16500	.042
			37	7500	8900	23000	.178
			38	7000	10300	25000	.124
			44	7500	14400	33000	.069
Single Taper			6	8500	12200	32000	.133
			39	13500	17500	22600	.354
Average				7650	12837	24350	.128
Serrated	10	005	45	10000	15500	15800	.015
	10	010	46	22000	27500	27500	.008
	10	015	47	45000	50000	50000	.012
	10	020	48	43000	45000	45000	.003
Serrated	10	018	38	23000	37500	37700	.012
	10	015	40	25000	35000	35000	.01
	10	007	41	16500	23800	24200	.015
	16	007	43	21000	27200	27200	.006
	64	002	42	15000	16000	16000	.010

FIG. 9.—RESULTS OF TESTS ON 3-INCH, 12-GAGE COLD-DRAWN TUBES.

To discover how much roughening was desirable, a series of tests was made with straight holes, in which a shallow, square thread was cut with a pitch of ten threads to the inch, and from 0.005 to 0.020 inch deep. The tube ends were not flared. Nos. 45, 46, 47, 48 show the results from these serrated holes, in which it appears that the slipping point may be very greatly elevated by this means.

With serrations 0.005 inch deep the surface is barely rough-

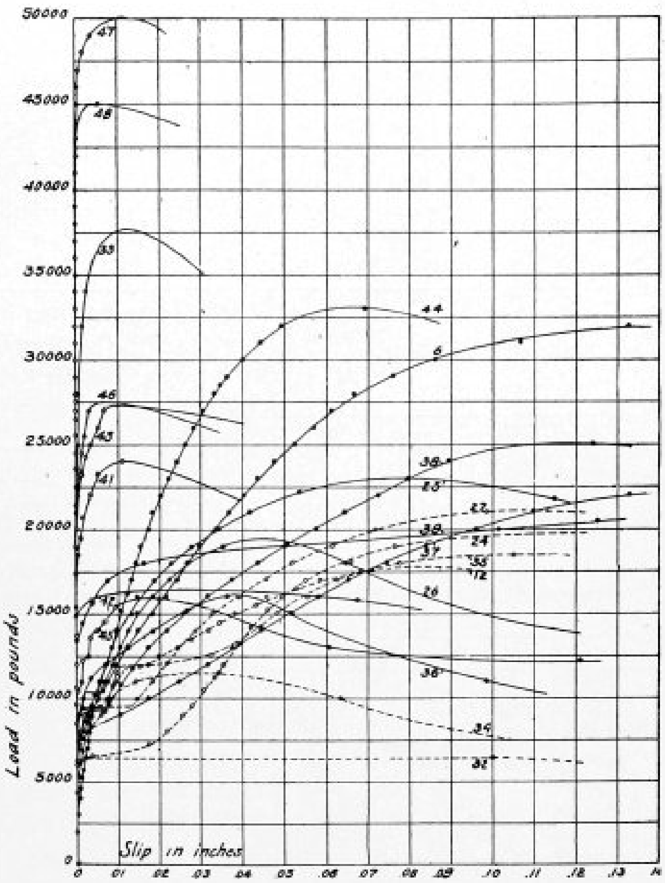


FIG. 10.—3-INCH TUBES ROLLED IN 1-INCH PLATE.

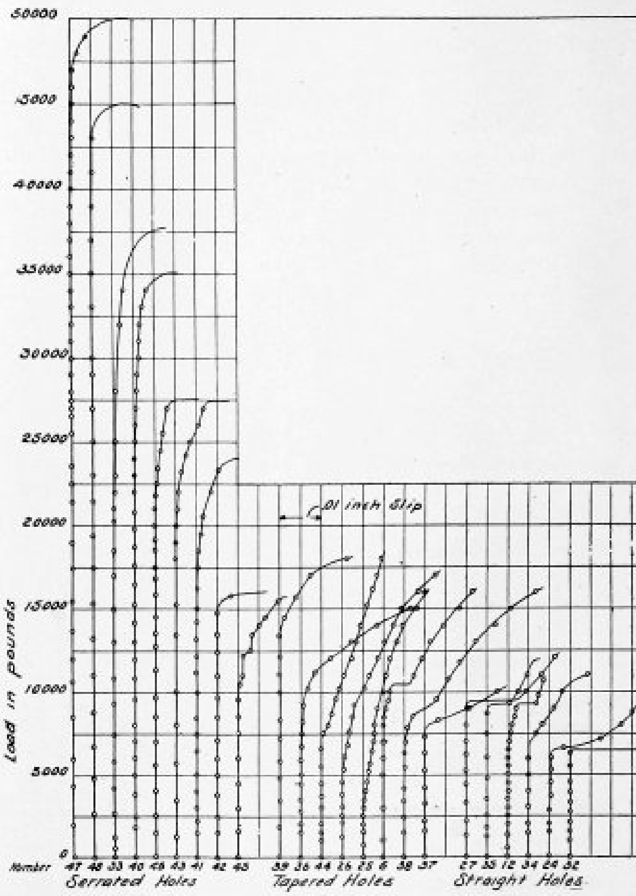


FIG. 13.—INITIAL SLIP OF 3-INCH TUBES SHOWN IN FIG. 10.

ened, and the slipping occurs at 10,000 pounds. This is increased successively to 16,000, 22,000 and 45,000 pounds by increasing the depth of the grooves to 0.007, 0.010 and 0.015 inches, respectively. The elastic limit of the tube is reached in tension at about 34,000 pounds, and this load was exceeded by a number of the tubes before there was any slip. Fig. 12 shows a section of tube 47 which resisted 50,000 pounds before slipping. The tube was stretched 0.25 inch in a length of 3 inches, and reduced 0.11 inch in diameter.

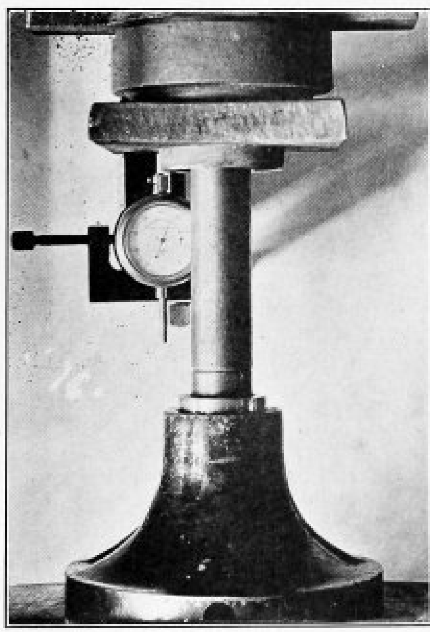


FIG. 11.

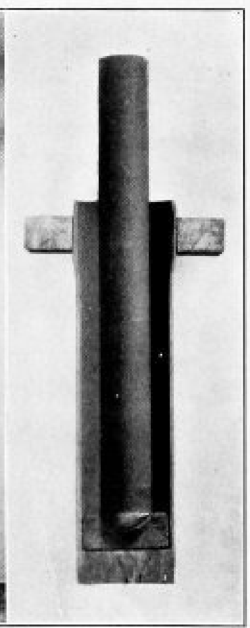


FIG. 12.

This figure also shows the method of applying stress to all the tubes. A plug welded into one end of the tube carried a loose hemispherical seat for the end of a central column which received and transmitted the stress from the testing machine, as shown in Fig. 11. The slip was measured by a dial micrometer recording the movement of the projecting end.

In test 41 the hole in the tube sheet was serrated by rolling with an ordinary flue expander, the rolls of which were grooved 0.007 deep and 10 grooves to the inch. This method of serrating is easy and can be recommended where tubes are slipping and are required to carry an unusual load.

This tube has the slipping point raised to three or four times the usual value. It appears that with serrations about 0.015 inch deep, giving an abutting area of about 1.4 square inches in a seat 1 inch wide, that the maximum strength is reached, as shown in tube 47.

SUMMARY.

a The slipping point of a 3-inch, twelve-gage Shelby cold-drawn tube rolled into a straight smooth machined hole in a 1-inch sheet occurs with a pull of about 7,000 pounds.

b Various degrees of rolling do not greatly affect the point of initial slip.

c The frictional resistance of such tubes is about 750 pounds per square inch of tube-bearing area in sheets ⅝ inch and 1 inch thick.

d For a higher resistance to initial slip other resistance than friction must be depended upon.

e Serrating the tube seat in a straight machined hole by rolling or cutting square-edged grooves about 0.01 inch deep and ten pitch will raise the slipping point to three or four times that in a smooth hole.

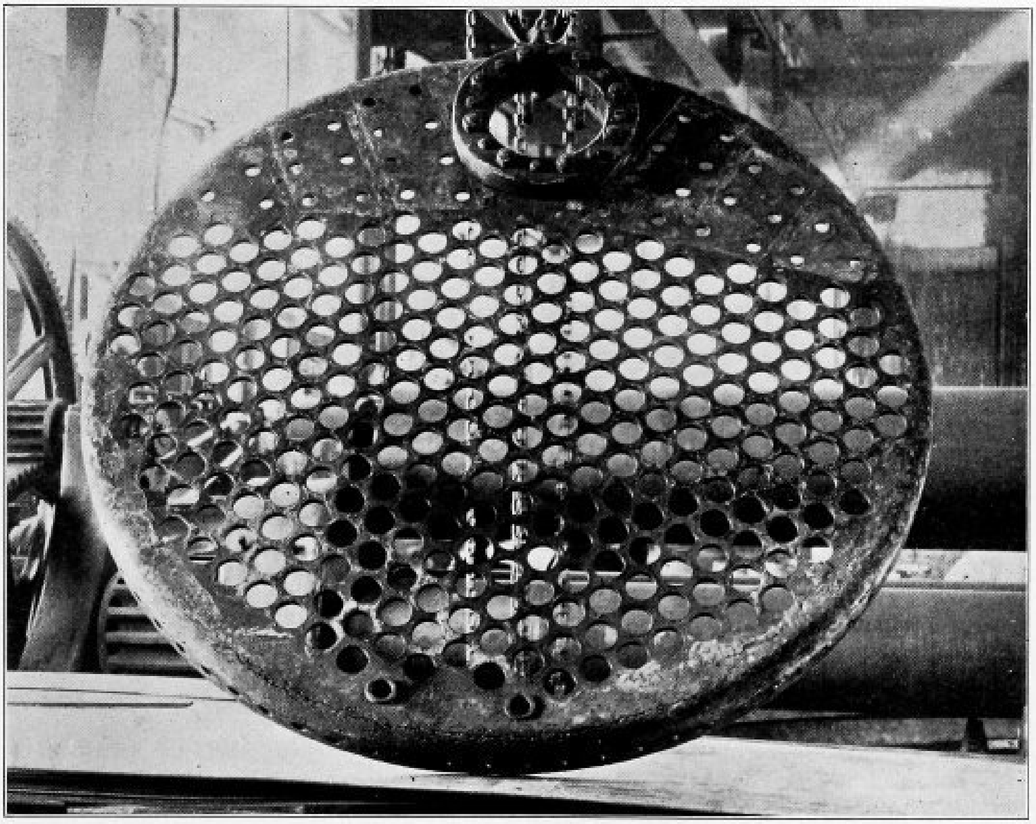
f It is possible to make a rolled joint that will offer a resistance beyond the elastic limit of the tube and remain tight.

"A Stitch in Time."

The beneficial results of rigid internal inspection of boilers is shown in the following instance: The flue sheet shown in the photograph was recently removed from one of the locomotives in service on the Delaware, Lackawanna & Western Railroad, because there was an indication of a leak in the smoke-box of the boiler. The leak, however, did not give any indication that the flue sheet was in the cracked condition which is apparent in the photograph. Without efficient internal inspection the condition of this sheet might not have become known until it had resulted in a boiler failure.

Methods of Welding Flues, Meadville Boiler Shop.*

At the Meadville boiler shops the process of welding and handling flues is as follows: The flues are sent from the machine shop to the flue rattlers, which are just outside of the shop. Four men handle them on a three-wheeled cart of our own design. About one hundred and fifty flues are put in each rattler and allowed to remain for nearly ten hours. Our next operation is to cut off the ragged end. This is done cold, by a cutter revolving on the flue. We then heat the end to be welded in the furnace, and, when hot, it is brought out and jammed on a mandrel, which flares it out. The new end is placed on the mandrel, and the flue is jammed onto it. We then take a welding heat and finish the work with a rotary welding machine having a speed of 230 revolutions per minute. While still hot the flue is swedged.



CRACKED FLUE SHEET FROM LOCOMOTIVE BOILER.

The furnaces we use are of our own design and construction, each furnace having three parts for heating purposes and each part just large enough to heat one flue. We use oil for fuel and direct blast on the furnaces.

Our swedging machine is also of our own design and construction. It is operated by an air cylinder, the piston of which is connected to the upper die, the lower die being stationary. There is a hole in each die of the size to which the flue is to be swedged, and by stepping on a foot lever the upper die closes down tight on the lower one, thus squeezing the flue.

The new ends which we use are beveled, and we are now constructing a machine which will grind these ends immediately before being used. Although we have not used it, we think it will help us materially in the welding.

We pay $2.10 per hundred for swedging and welding 2¼-inch flues, while the 3-inch size costs us $2.45 per hundred.

* From a paper by Joseph Northend, read before the convention of the International Railroad Master Blacksmiths' Association.

Finding Out the Reason Why.

We don't hesitate to turn to the doctor to tell us the reason why when we are ill, and to seek through him the means of cure. But in our industrial life we have been far more inclined to act as our own doctors, thereby frequently entailing expense and disaster which might have been avoided had we called for expert advice. But the independent expert easily solves our problems, answers our puzzling questions, and sets us straight again. Examples of his value are multiplying in just such simple experiences as the following:

A power station recently experienced considerable trouble from the breaking of boiler-tube cap bolts on their watertube boilers. The bolts looked all right, but every time a boiler was cooled down and brought up to steam again a number of the bolts would break off short. The matter became so serious that several bolts were sent to an expert chemist for analysis and the determination of the same. The chemist immediately discovered that the bolts were made of overheated steel, instead of the best quality of wrought iron, for which the company had paid, and supposed they were obtaining. A change of material at once removed all trouble.

Boiler Fittings.

BY WILLIAM J. RANTON.

There are now so many different types of fittings and appliances placed on a steam boiler that it is very hard for an inspector to name them, and while no doubt some of them are very useful, a great many of them are neither useful nor ornamental. A boiler inspector has more chance for seeing the great variety of appliances that are in use than the ordinary every-day engineer, visiting as he does from one to two hundred steam plants every month, while the engineer probably does not visit ten in a year. We will mention, however, only the fittings that are needed, namely, the safety valve, steam gage, water gages, blow-off and surface blow-off cocks, injectors, pumps, their connections and heater; grates and stack; also say a few words on the construction of the furnace.

A well-constructed furnace with good grates and plenty of natural draft will pay for itself in the saving of fuel on an ordinary sized boiler in the first six months' operation of same; the stack never can be too large for any plant; a damper will take care of the draft. Now as to the safety valve, there are at least three kinds, the pop or spring-loaded valve, the lever safety valve and the dead-weight safety valve. The common lever, or ball and lever, safety valve is in more general use than any other type. The boiler manufacturers make a specialty of supplying it in preference to the pop valve, because it is cheaper, and purchasers simply call for a safety valve; but all first-class specifications should call for pop valves, as a good pop valve is as far superior to the other types as the electric light is to the tallow candle.

A safety valve is a necessary appliance designed to prevent the boiler pressure exceeding a certain limit. It is supposed to open or lift up, and should do so, when that pressure is exceeded, and allow the surplus steam to escape, until the pressure has fallen a little below the limit, then should close tight again.

Safety valves are made with beveled seats, generally beveled to an angle of 45 degrees. The United States Government rule for required size of safety valve is for spring-loaded safety valves, 1 square inch area of valve for every 3 square feet of grate surface, and for ball and lever safety valves 1 square inch of area for every 2 square feet of grate surface.

The English rule is, when natural draft is used, allow half a square inch area of valve for each square foot of grate surface, no matter what type the valve is.

The French rule, which is also the same rule adopted and in use in the city of Philadelphia, is multiply the area of the grate surface by 22.5, add the constant 8.62 to the pressure allowed per square inch, and divide the first by the second; the result is the area required. Thus, suppose you had 30 square feet of grate surface, $30 \times 22.5 = 675$. If the pressure was 80 pounds, $80 + 8.62 = 88.62$, then $675 \div 88.62 = 7\ 6/10$ square inches area; as a 3-inch valve has an area of 7.06, it would not comply with the law, and a 3½-inch valve would be required. This grate surface, under United States Government rule, would require a valve 4 inches in diameter, as the area of a 3½-inch valve would be only 9.62 square inches, and 9.62 multiplied by 3 would make your grate surface 28.86 square feet, and in this case pressure has nothing to do with the size of valve, no matter what your pressure is; the law states "area of valve to grate surface."

As to testing the safety valve to find out whether same is correct or not, there is only one proper way to do it, and that is with a correct steam gage, and when boiler is under pressure, adjusting the valve to the pressure required as indicated on the steam gage.

A dead-weight safety valve is one with a long stem connected on the valve, the weight having a hole drilled partly through it, the same diameter as the valve stem. These valves can be tested by finding the pressure on the valve and overcoming same by the weight of valve, stem and weight combined; thus a valve 1 inch in diameter, the pressure required being 25 pounds, a dead weight against this pressure of 19 6/10 pounds would be required the area of the valve would be $.7854 \times 25 = 19.635$.

Safety valves should be kept cleaned and frequently tested, the pressure should be allowed to run up to blowing-off point at least once a day, and if it is not practicable to do this they can be tried by hand, but in this case it is impossible to determine the exact amount of force used to raise it to the blowing-off pressure.

It is also absolutely necessary that every boiler should be provided with a first-class steam gage. New York State has a good law, but it is not very strictly enforced. This law requires that there "shall be a steam gage independent of the steam gage in the boiler room, connected directly to the boiler, but placed in the engine room.

The Bourdon type of gage is the best steam gage. The principle on which it is constructed is a flattened or oval curved tube closed at one end, which, when subjected to the internal pressure, becomes straightened out.

All steam gages should be connected to the boiler with a syphon. The steam condenses in the syphon, thus allowing water to come in contact with the spring instead of steam. There should also be a stop-cock connected between the syphon and the gage, so that the gage may be taken off at any time and tested.

Another great trouble in this fitting is that the smaller the gage can be made the more willing the boiler manufacturer is to furnish it with the new boiler, and on this account I have known gages furnished to be so small that engineers and firemen grow blind trying to find figures on the dials of steam gages. This is not intended as a joke. At a very little extra expense a large steam gage could be furnished, and it would give far better satisfaction, as the smaller sizes are very cheaply constructed.

Every boiler should be provided with three gage cocks, the lowest gage cock to be placed at least 2 or 2½ inches above the highest point in boiler where heat comes in contact with plate, the next about 3 inches above the lower one, and the upper cock about 3 inches above the second one. They should be opened frequently and kept in good working order.

Glass water gages, as is well known, consist of a glass tube, the top and bottom being connected with proper fittings to the steam and water spaces of the boiler; they are supposed to show the level of the water in the boiler, and if fitted close to the boiler are generally reliable. They should be so fitted that when necessary to renew or clean them they could be shut off from the pressure without shutting the boiler down. There should also be a drip cock placed at the bottom of the glass in the fitting, so that glass could be blown out frequently.

On stationary boilers a water column or combination box is now in general use, being connected at bottom to the water space of boiler and at top to steam space; into this column is fitted the gage cocks and water glass; the lower or water end of column should be fitted with a valve in order that it may be blown out regularly, and there should be no reduction of size in the blow-out and supply to the column. The water-column connections to boiler, especially at lower connection, should be made with crosses, instead of elbows or tees, and brass plugs used in the crosses, so they may be removed easily and connections cleaned when boiler is empty.

The common practice among steamfitters is to use elbows, and the engineer should not under any circumstances allow a connection to be made that cannot be got at to clean when boiler is down for cleaning purposes.

The blow-off cock is the least used and most abused fitting on a boiler. How many engineers open the blow-off cock on their boiler every day, as they should? The proper place for the blow-off cock is in the bottom of the shell at rear end of boiler; the center of the opening should be about 10 inches from the back head, and the boiler should be so set that it would be lower at rear end than it is at front end; about 1 inch in 12 feet is good practice.

The piping between blow-off cock—that is, inside of back wall—and boiler should be protected from the heat and gases; there are several ways of doing this, but the best way is with a brick pier built V-shape; this gives freedom to the pipe and a chance to examine it for any defects. This connection and the blow-off cock should be absolutely free from leakage, and in addition to the bottom blow-off cock every boiler should be provided with a surface blow-off. It is one of the best scale-preventers that can be procured, as by using the surface blow-off several times a day when boiler is under pressure the scum or foreign matter can be removed, which, if allowed to remain, settles and forms the scale which every engineer wants to get rid of. When once attached to tubes and shell of boiler it is almost impossible to remove.

Another valuable appliance or fitting is the injector, especially if you are not fortunate enough to have a heater. A good pump is always necessary, even when you have an injector. The pump should be of such size so that it could be regulated to run continuously, as a regular and constant feed is better than occasional feeding. The connecting of check and other valves between the pump or injector and boiler is also a matter of importance. A good stop-cock should be placed between check valve and boiler (a stop-cock is better than a globe or gate valve). It should be placed close to the check and as close to the boiler as possible, but convenient to get at.

Grates should be carefully selected; a long grate is a nuisance; two or three short grates are better than one long grate; they are less liable to warp and burn out; are lighter and easier to replace. A good shaking grate is preferable to the plain grate.

As before stated, have your stack large enough, and same provided with a damper as close to the boiler as possible. If the boiler has an uptake or smoke connection between boiler and stack, the damper should be placed in it. Now, with good setting and good appliances, there should be no trouble in making steam easily and economically. Of course, the furnace will have to be properly constructed; it should be large and roomy, so as to allow of good combustion of the gases before they are hurried over the bridge wall on their way to the tubes. The walls should be double, having a considerable air space between them to avoid loss of heat, and the fire-box sides should be lined with fire-brick. The bridge wall should be hollow and so built that the passage of the gases will have the proper ratio to the area of the grate surface, namely, one-fifth; in fact, the whole inside walls and the back wall should be of fire-brick.

The space under the boiler behind the bridge wall and the space at the back end of boiler must be considered as a prolonged combustion chamber, and it is during their passage through this chamber that the gases escaping from the furnace unconsumed must be burned, and to effect this while they are at the proper temperature air must be introduced near the bridge wall.

Mr. George Tower, formerly instructor of mechanics and chemistry in Dartmouth College, a man of great experience—chief engineer in the U. S. Navy, also supervising inspector of steam boilers, and who, as is well known, installed some of the largest steam plants in the Eastern States—has said in his treatise on this subject that air cannot be supplied through the grate bars, but can be above the fuel in the furnace, and also at and behind the bridge wall, the air being supplied from the spaces between the walls of the furnace and the hollow bridge wall.

This air should be produced in many fine streams to promote its thorough admixture with the gases more rapidly. In a return tubular boiler this extra provision for air is absolutely essential, as the tubes act as extinguishers, no flame being able to penetrate them to a greater length than 8 or 10 inches, hence any gases entering them unburned is wasteful so far as the evaporative power is concerned.

The greatest effect of the heat on the boiler bottom takes place at some point between the bridge wall and 12 or 15 inches back of it, and it is well to locate the bridge wall so that it is a considerable distance away from the circular seam on account of the double thickness of plate. Either lengthen your furnace to clear your seam or shorten it and make it wider, which would give the same grate area.—*The Universal Engineer.*

Diagram for Finding Efficiency of Riveted Joints.

BY J. P. MORRISON.

This chart is based upon a tensile strength of 60,000 pounds per sectional square inch for steel plates, and a shearing strength of 40,000 pounds per sectional square inch for steel rivets in single shear. Rivets in double shear are considered as having 180 percent the strength of rivets in single shear. The efficiency of the net section would not be changed if sheets of 55,000 or 65,000 pounds tensile strength were used, or if rivets having an ultimate shearing strength of 42,000 pounds were used, but changing the tensile strength of the steel or the shearing strength of the rivets, would change the efficiency of the rivets as compared with the strength of the solid plate.

If steel of 65,000 pounds tensile strength was used, the efficiency of the rivets would decrease by 8 1/3 percent; or if steel of 55,000 pounds tensile strength was used, the efficiency of the rivets would be increased by 8 1/3 percent. Should rivets of 42,000 pounds shearing strength be used, the efficiency of the rivets will be increased by 5 percent.

The efficiency of the rivets varies inversely as the thickness of the steel, and also inversely as the pitch of the rivets.

The efficiency of the net section for any pitch is equal to 100, less than double the efficiency of the net section for twice the pitch, or efficiency for (2 pitch $\times$ 2) $-$ 100 $=$ efficiency of net section.

The efficiency of the net section for any pitch equals one-half of the efficiency for net section for half the pitch plus 100, or efficiency for

$$\frac{\frac{\text{Pitch}}{2} + 100}{2} = \text{efficiency of any net section.}$$

Bearing these simple formulæ in mind, with the aid of the chart the reader will be able to determine the efficiency of any riveted joint.

EXAMPLE NO. 1.

We have a boiler constructed of steel of 60,000 pounds tensile strength ½-inch thick. The horizontal seam is double-lap riveted. The rivets are 1 inch in diameter, the rivet holes 1 1/16 inches in diameter, and the pitch of rivets 3½ inches, find the efficiency of the joint.

The first step is to locate the pitch of the rivets on the left-hand scale, marked greatest pitch. We find that 3½ inches is not given on this scale, so we will take double the pitch, bearing in mind that the efficiency of the rivets varies inversely as the pitch. So the efficiency found using 7 inches pitch will be one-half the actual efficiency. From the 7-inch mark on the greatest pitch scale, follow the horizontal line to the left until the line representing the diameter of the rivet hole is met. This line is, in this case, the one marked 1 1/16 inches. From where we strike the rivet-hole line, proceed downward until the diagonal line representing the thickness of the shell plates is reached. This is the ½ inch line. From this point go horizontally to the right until the line marked double-riveted lap is met, going upward from this point and touching the efficiency of rivets scale at 33¾ percent. Doubling this efficiency, as has been stated above, we find a rivet efficiency of 67.5 percent.

We will next consider the net section. Locate 3½ inches on the scale marked pitch of rivets in section considered. Follow the horizontal line to the right until the line representing the diameter of rivet hole is met; from this point go downward, meeting the efficiency of net section scale at the division 69.5 percent. This is the efficiency of the net section as compared with 67.5 percent for the rivet shear.

If in the boiler considered above the steel had been of 55,000 pounds tensile strength, the efficiency of the rivets would be increased by 8 1/3 percent of the efficiency, which is 5.6 percent of the solid plate, making an efficiency of 67.5 + 5.6 = 73 percent. But should the tensile strength of the steel be increased to 65,000 pounds, the efficiency of the rivets in shear will be decreased to 62 percent.

EXAMPLE NO. 2.

Consider the same boiler plate as in the previous example, but assume a triple-lap riveted seam, using ⅞-inch rivets, 15/16-inch holes and pitch the centers 3½ inches as in the previous example.

We proceed as before by taking 7 inches as the pitch. Go toward the left along the horizontal line, meeting the 15/16-inch diameter of rivet-hole line, then downward, meeting the ½-inch plate line, then to the right to the line marked triple-riveted lap, then up to the efficiency scale, which we touch at 39.5 percent. This efficiency we double, on account of doubling the pitch, and have an actual rivet efficiency of 79 percent.

The net section is found, as previously explained, by going from the rivet-pitch scale to the right, meeting the 15/16-inch line. and then going downward to the scale marked efficiency of net section, which we strike at the 73 percent mark, which, being the smallest efficiency, would determine the strength of the seam.

We will next consider a triple-riveted butt joint: Rivets, ⅞ inch in diameter; rivet holes, 15/16-inch diameter; pitch of rivets, 7 inches; thickness of shell plate, 7/16 inch; tensile strength of steel, 60,000 pounds.

From the 7-inch division on the pitch scale, pass horizontally toward the left to the line representing 15/16-inch diameter of rivet hole, then downward to the 7/16-inch plate line. From this point we should pass toward the right, but it will be seen that the line marked triple-riveted butt passes under the point where the plate line is met, so it will be necessary to go toward the left. However, our rivet-efficiency scale is graduated to but 110 percent, and we find that by going horizontally to the left we do not touch our triple-riveted butt line within the limits of the chart, so our rivet efficiency is greater than 110 percent of the solid plate, and it will not be necessary to know the exact efficiency.

The efficiency of the net section is found, as previously explained, by locating the 7-inch division of the right-hand scale. From this point we pass to the right until the 15/16-inch diameter of rivet hole line is met, then downward to the net section-efficiency scale, where we find 86.5 percent, which is the smallest efficiency and determines the strength of the seam.

We find the efficiency of quadruple-riveted butt joint in very much the same manner as we find the efficiency of the triple-riveted butt joint. Excepting when we find the efficiency of the net section, one of our formulæ must be used.

We will find the efficiency of a quadruple-riveted butt joint: The shell plate ⅜-inch thick, of 60,000 pounds tensile strength, diameter of rivets ¾ inch, of rivet holes 13/16 inch, and pitch of rivets 14 inches.

We find the same condition exists as with the triple-riveted butt joint regarding the efficiency of the rivet shear. The efficiency is greater than the 110 percent of the strength of the solid plate, so the line representing quadruple-riveted butt joints is not met within the limits of the chart. However, had we taken 7/16 inch as the thickness of the shell plate, the efficiency of the rivets would have been but 100 percent, and had the thickness been taken as ½ inch, the rivet efficiency would have been found by passing to right from the point where the plate line is met, and the quadruple-riveted butt line would have been crossed, and passing up the vertical line to the rivet-efficiency scale 87.5 percent will be found to be the efficiency of the rivets. However, to return to the consideration of the ⅜-inch plate, quadruple butt-joint problem, we have found that the efficiency of the rivets is more than 110 percent of the strength of the solid plate.

We will next find the efficiency of the net section. The pitch, 14 inches, is not given on the scale marked pitch of rivets in section considered, so we will take one-half the pitch, or 7 inches, and pass horizontally until the diameter of rivet-hole line is met, then downward to the efficiency of net-section scale, which we touch at about 86.5 percent.

We have taken one-half the pitch instead of the actual pitch, so, remembering our formula, we have

$$\frac{\frac{P}{2} + 100}{2} \text{ or } \frac{86.5 + 100}{2} = 93.25 \text{ percent, the least efficiency}$$

of the quadruple butt joint just considered.

The efficiency of a quadruple butt joint as found above may be taken as the smallest efficiency, so long as the diameter of the rivet hole is double the thickness of the shell plate, but when very thick plates are used it is not practical to use rivet holes of a diameter twice the thickness of the steel, and other modes of failure have to be considered.

For example, consider a case where ¾-inch shell plates, 1⅛-inch rivets, 1 3/16-inch diameter rivet holes, a pitch of 15½ inches, and a quadruple butt joint are used. We find the efficiency of the rivets to be slightly greater than 110 percent of the strength of the solid plate, and the efficiency of the net section along the line of the outer row of rivets to be 92 percent of the strength of the solid plate.

Now we will determine the efficiency of the joint, considering the strength of the rivet *"A"* in shear, and the strength of the net section *"B-C"* (see the drawing of the quadruple-riveted butt joint on the chart).

First, find the efficiency of the rivet *"A"* by locating the pitch of the rivets on left-hand scale and following the method explained, until the thickness of plate line is met. From this point follow the horizontal line until the diagonal line marked rivet *"A"* in shear-net section *"B-C"* considered is met. Then pass up the vertical line to the rivet-efficiency scale, which we touch at 6.5 percent. This is the efficiency of the rivet *"A"* in shear, to which we add the efficiency of the net section along the line *"B-C."* The pitch of rivets along this line is 7.75 inches, and the efficiency of the net section is found to be 84.75 percent, making a total efficiency of 6.5 + 84.75 = 91 percent.

We will next determine the efficiency of rivets *"A-B-C"* in shear and net section *"D-C."* Find the efficiency of the rivets in same manner as used in the preceding case, except that we pass vertically toward the rivet-efficiency scale from the point where the diagonal line marked rivets "*A-B-C*" in shear-net section *D-E* considered is met. We reach the rivet-efficiency scale at the 19.5 percent division. The pitch of the rivets along the line *D-C* is 3⅞ inches, and we find the efficiency of the net section to be nearly 69.5 percent. To this is added the 19.5 percent efficiency of the rivets "*A-B-C*," making a total efficiency of 89 percent, nearly, for this mode of failure. We have found that the efficiency of the rivets in shear in this joint is over 110 percent; that the efficiency of the net section, along the outer row of rivets, is 92 percent; that the efficiency of rivet "*A*" in shear and net section "*B-C*" is 91 percent; and that the efficiency of rivets "*A-B-C*" in shear and net section "*D-E*" is but 89 percent. The latter efficiency being the smallest, determines the strength of the joint.

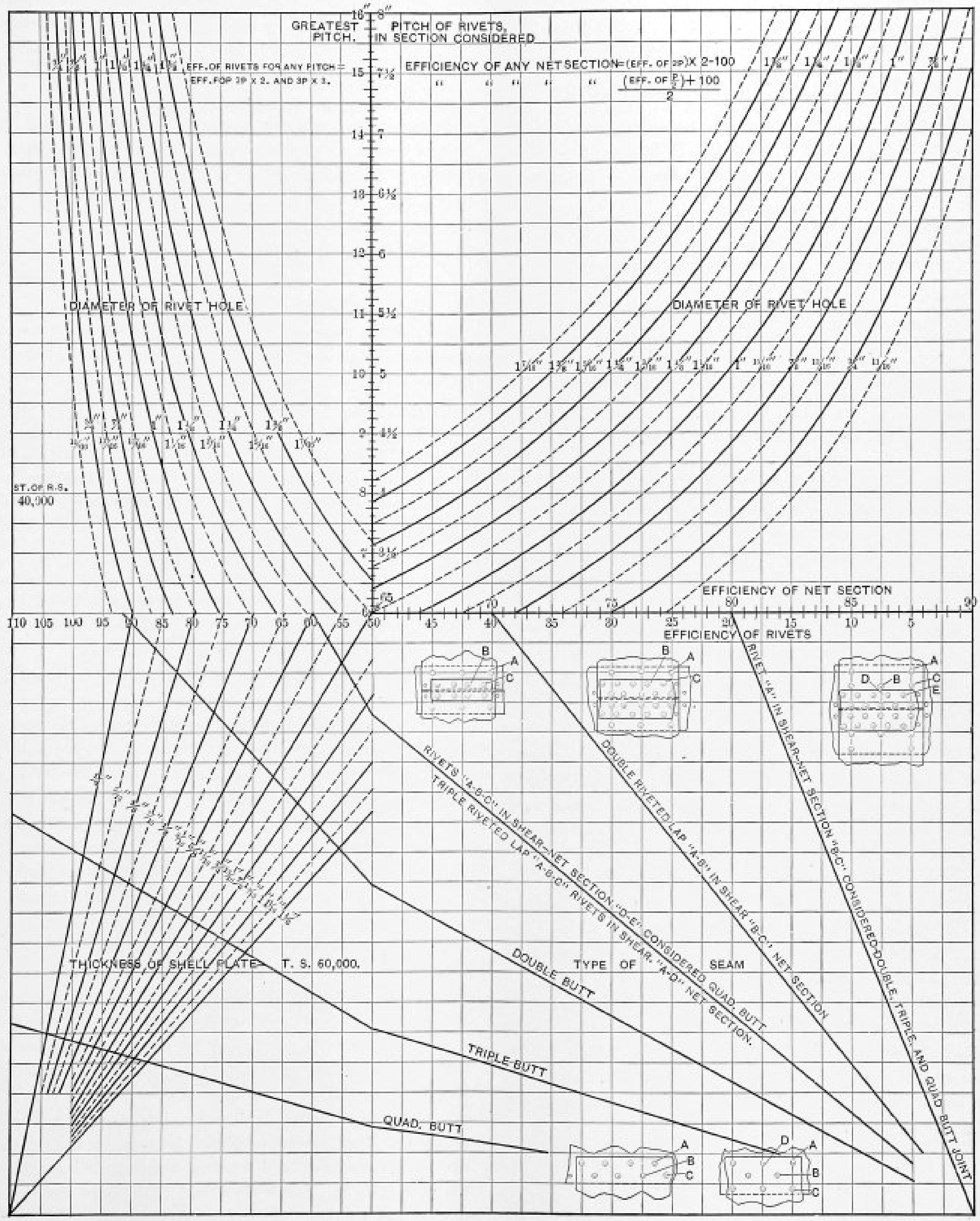


DIAGRAM FOR FINDING THE EFFICIENCY OF RIVETED JOINTS.

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.

The edition of this issue of The Boiler Maker comprises 5,500 *copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

Self-Cleaning Ashpans for Locomotives.

Congress has passed an act, which will go into effect Jan. 1, 1910, requiring all locomotives to be equipped with some efficient form of self-cleaning or self-dumping ashpan. This law was enacted for the protection of engineers and firemen, and is thoroughly creditable in every way. It is now up to the boiler makers and designers, however, to develop a suitable type of ashpan which can be cheaply built, easily installed, and which at the same time will meet all the requirements of the law. As yet it seems to be impossible to say what is even the best type of apparatus to be used for this purpose. A number of different arrangements have been tried with more or less success, and we would suggest that all of our readers who have had any experience with devices of this sort, which have given indications of successful operation, send us plans and a short description of them for publication, so that they may be criticised and discussed by others. Opinions thus brought to bear on the subject from various sources would undoubtedly do much towards the development of the perfect type of self-cleaning ashpan.

Regarding the Prize Contest.

Since announcing in our last issue that prizes of $40 and $25 would be awarded for the best articles on repair jobs submitted to us before 12 o'clock noon, March 1, 1909, we have had a number of inquiries requesting more specific information regarding the conditions of this contest.

Each paper submitted should describe some specific job of repair work, and not simply treat of the general methods of doing repair work. Of course, in each case the tools used and exact procedure followed in carrying out the work should be given in detail, as well as some idea of the time required, cost of the job, etc. The articles will necessarily be judged on very broad lines, as it is hardly likely that more than two or three of them will describe the same kind of repair job. For instance, of two papers, one describing a method of patching a flue sheet, and the other describing the best way of handling a bulged plate on a tubular boiler, that paper would be considered the better which, in the opinion of the judges, shows that the work has been performed in the most scientific and practical way at a minimum cost for obtaining a thoroughly reliable and durable job.

Resistance of Rolled Boiler Tubes.

On another page of this issue we publish an article by Professors Hood and Christensen on the "Slipping Point of Rolled Boiler Tube Joints," which presents a number of new and valuable ideas. So far as we have been able to ascertain, the only tests which have hitherto been made on the resistance of such joints have been made to determine the ultimate stress at which the tube pulls out of the sheet, regardless of the fact that, long before this point is reached, the tube must have slipped to a considerable extent in the sheet and caused excessive leakage.

In the article mentioned it is pointed out that the resistance of the rolled tube, due to friction, prevents the tube from slipping in the sheet until a certain fairly definite stress has been reached, after which the tube will continue to slip, although the joint will not fail until this stress has been approximately doubled. It is evident that since this action takes place no tube should be stressed beyond the slipping point if a tight joint is to be maintained. Fortunately, however, there are means of raising the slipping point, so that the joint can be made to offer a resistance even greater than the elastic limit of the tube, and still remain tight. This result cannot be effected by various degrees of rolling, but it can be accomplished by serrating the surface of the hole, so that the tube is gripped and a shearing resistance of the metal offered in addition to the frictional resistance. This is practically the same effect as obtained with ordinary stay tubes, except that with the plain tubes and serrated hole this result can be accomplished more cheaply and expeditiously than by carefully tapping the holes and threading the tubes.

Nearly thirty years ago tests were made to determine the effect on the holding power of a flue resulting from flaring the end of the tube which projects beyond the tube sheet. It was found that flaring the tube in this way increased its ultimate holding power to about four times the original amount. While this would seem to be a great advantage it is now shown by Professors Hood and Christensen that flaring tubes in this way does not have any material effect upon the slipping point of the tube, so that even though the ultimate holding power is increased, the slipping point, and consequently the point at which we may expect leakage to occur, has not been changed. The same is true of tubes expanded into tapered holes.

Convention Notice.

At a meeting of the officers and executive committees of the International Master Boiler Makers' Association and the Boiler Makers' Supply Men's Association, held at the Seelbach Hotel, Louisville, Ky., Nov. 15, 1908, it was decided to hold the next convention at the above hotel April 27, 28, 29 and 30, 1909. The hotel has made the following rates: European Plan—Single room, without a bath, $2 per day; two in a room, $3 per day; $1.50 extra for each additional person in the above rooms. Rooms with a bath, one person, $3, $3.50, and $4; two persons, $4, $4.50 and $5. Any person desiring American-plan rates will find several first-class hotels within a radius of one or two blocks.

On account of the limited number of rooms, it will be absolutely necessary that reservations be made in advance. The Supply Men's Association has reserved the whole third floor for those who desire to make exhibits.

COMMUNICATION.

Holding on.

EDITOR THE BOILER MAKER:

In a great many shops they have a great deal of trouble in getting the rivets tight, and in most all cases it is up to the holder-on; but in my opinion it is as much due to the man behind the gun as it is to the one on the other end. The proper tools should be used in the proper place. In most all up-to-date shops tools for all kinds of jobs can be found. The jam hammer always makes a good, tight job on a mud-ring or a smoke-box, or in any place where it can be used. With a good brace for it and the proper size cup for the rivet it will keep the work up tight; but, of course, if the job is not fitted up right, or laid up properly in place, you cannot expect to get good results. With the job laid out right, good, true holes and a good jam hammer, I cannot see any reason why, under proper conditions, the rivets should not be tight. Of course there are lots of places where a jam hammer cannot be used; then the wedge bar, dolly bar or sledge must be used. The sledge is all right if a hole is drilled on the face of about the same size as the rivet head to be driven. Countersink this a little and it will shape the head up and keep the sledge from sliding. The hook placed so that you can get a good hold on it will hold them up. The sledge is also good for stay-bolts; that is, when the holes are drilled up to size and tapped out right, and the bolts run in with threads that you can set with a motor or wrench, not the kind you run in and set with your fingers, the sledge will be all right. The weight of it bounding back and forth will make the bolts tight while pounding them over. Do not let the head get back about an eighth of an inch from the sheet, for under these conditions you cannot expect good results. Keep the sledge up in place, then things will be different.

HARRY JEWELL.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—What is the actual length of time it has taken a boiler maker and helper to remove one or more tubes and replace them with new ones in the following types of boiler: Horizontal tubular, Manning vertical, Wickes vertical, Cook vertical, B. & W. and Cahall watertube? Please give the diameter, length and number of tubes, and also the length of time which the boiler has been in service.

It is desired that this question be answered by readers of THE BOILER MAKER who are themselves practical boiler makers and have had considerable experience on this particular point. H. W.

PERSONAL.

J. H. MARTIN has accepted the position of foreman boiler maker with the M. J. & K. T. R. R., Mobile, Ala., vice T. J. Price, resigned.

J. M. WILLIAMS has resigned as foreman boiler maker of the L. & N. R. R. shops at Mobile, Ala., to accept a position with the Gulf City Boiler Works of the same city.

C. A. RYDER, formerly assistant foreman boiler maker of the L. & N. R. R. shops at Mobile, Ala., has been promoted to foreman boiler maker of the above shops, vice, J. M. Williams, resigned.

R. A. WEBSTER has been appointed assistant foreman of the L. & N. R. R. boiler shops at Mobile, Ala.

THE immense shops of the M. & O. R. R. at Whistler, Ala., a suburb of Mobile, began on November 9 to operate on full time, 9 hours a day, six days a week.

J. E. WIESE, formerly foreman boiler maker of the Atlas Engine Works Company, Indianapolis, Ind., is now superintendent of the boiler shops of the Canada Foundry Company, Toronto, Ontario, Canada.

JAMES H. SHERIDAN, formerly with W. H. Atkinson & Company, Hoboken, N. J., has resigned to take the position of foreman boiler maker for the Pioneer Iron Works, Brooklyn, N. Y.

JOHN L. WALKER, formerly auditor for the Buda Foundry & Manufacturing Company, has resigned, to accept a position as manager of the "Use-Em-Up" socket department of the American Specialty Company, Chicago, Ill.

LOUIS M. HENOCH, who has been connected with Joseph T. Ryerson & Son, Chicago, since 1888, has severed his connection with that company, and intends to go abroad about the first of the year. He will probably be able to make some definite announcement regarding his future connections upon his return to this country. Mr. Henoch during recent years has served in the capacity of general sales manager and lately as secretary of the Joseph T. Ryerson Company, and in this capacity he has had general jurisdiction of sales, purchases and operations of this concern.

AMONG last week's arrivals from Europe was F. W. A. Joly, of Wittenberg, Halle, Germany, president of the Association of German Manufacturers of Fire Brick (Wirtschaftliche Vereinigung Deutscher Chamotte Fabrikanten), which he organized with the object of improving methods of manufacturing. The association has established standards of quality and shape, reducing the number of the latter and has studied the requirements of customers with reference to tensile strength, refractory qualities and uniformity of product. Mr. Joly is about to spend some weeks in this country to study American conditions, with a view of drawing therefrom applications for the industry of his country. He is in a position to offer to American manufacturers suggestions growing out of the experience of German makers which may prove of value to American manufacturers. His headquarters are at the Hotel Astor, New York City.

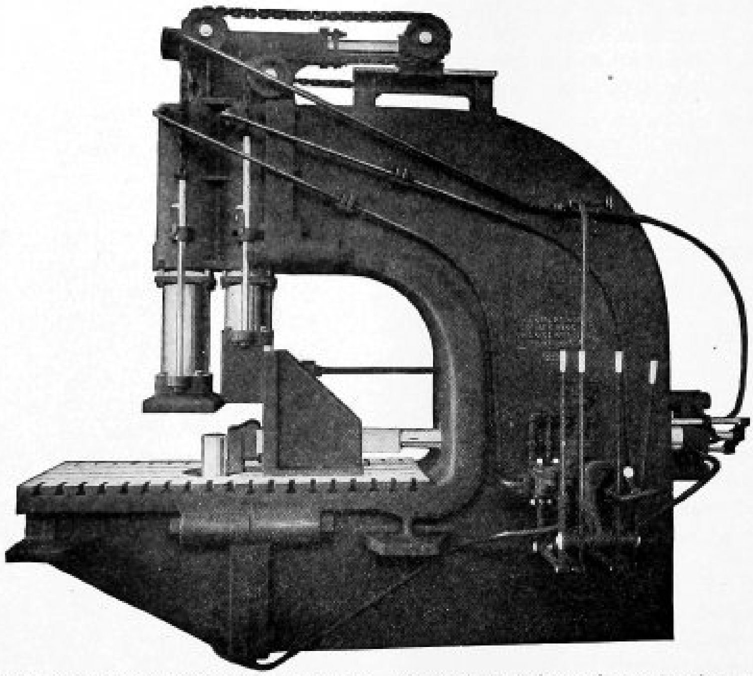
The Shop Foreman.

In these days of modern shop practice the foreman must be up to date to keep up with the times. He must be able to use his own ideas in many respects. Most all shops are equipped with the latest machinery. He must be able to operate the same, and get the best results from it. He must also be able to take hold and do any kind of a job in his line; lay out his own work, or, at least, understand when it is done right. He must be able to tell the men how to do a job and do it right; and in handling the men he must be able to place them properly, so that every one is busy, and not one gang waiting for the other to get out of their way. J.

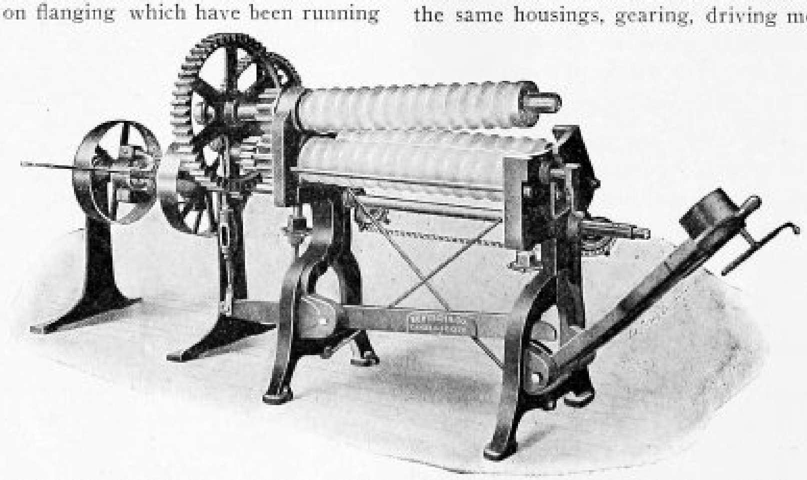
ENGINEERING SPECIALTIES.

Chambersburg Sectional Flanging Press.

The hydraulic sectional or universal flanging press, as built by the Chambersburg Engineering Company, Chambersburg, Pa., is furnished with two main vertical rams of either 65 or 100 tons pressure each, as may be desired, the stroke being



30 inches. The outside ram is used for clamping the plate and the inside ram for turning the flange when a head is being flanged in sections. When the complete head is flanged at one operation, both rams are coupled to one die. The horizontal ram has a capacity of 50 tons, 18-inch stroke and is used for squaring the flange and for upsetting work. The vertical ram in the base is of 45 or 75 tons pressure and 18-inch or 24-inch stroke, as may be desired. This ram is used for stripping the finished work from the dies, etc. The series of special articles on flanging which have been running



in the BOILER MAKER recently have amply described the wide range of work to which a machine of this type may be put.

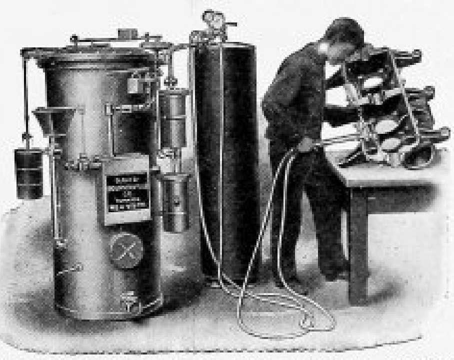
The frame is of air-furnace iron of special mixture and is of massive box construction. All the cylinders are steel castings and all the pistons and valves are outside hemp packed, having easily accessible glands. The main vertical and horizontal rams are provided with hydraulic pullbacks under constant pressure. An interlocking device on the valve levers for the main vertical and horizontal rams prevents them from fouling each other by being operated at the same time. The main vertical rams are arranged with positive automatic stops, which keep them from being pushed out of their cylinders, also prevents breakage of the pullbacks. Small relief-holes in all of the cylinders also safeguard against any damage being done by the operation of the rams without any dies or work in the machine. The press is designed for quick action, the valves being of ample size to admit water to the cylinders quickly, and the pullbacks being under constant pressure, insure rapid return of the operating rams.

Patented Forming Rolls.

Bertsch & Company, Cambridge City, Ind., have on the market a patented forming rolls, built with corrugated rolls for forming culverts, tanks, barrels, etc., out of corrugated sheets. This machine, which is made any required size, has the same housings, gearing, driving mechanism, etc., as their regular sheet metal forming and bending rolls. It is also built with their patented automatic opening and closing device with which the hinged end of the top roll is raised and supported, and the opposite end of the bottom roll is lowered simultaneously, in one operation, for removing the formed plate. The machine is opened in a few seconds by simply turning down the hinge. This is accomplished by the eccentric motion of the cam or lug on the bottom of the hinge, which lifts the adjacent end of the lever or bar, and lowers the opposite end, which is connected beyond the fulcrum with the top roll, thereby pulling down on that end of the roll and raising the hinged end. The bottom roll rests on a pivoted post, which allows it to raise and lower with the movement of the lever bar. As the post rests on the bar just beyond the fulcrum, its weight assists in pulling down on the top roll connection; hence, it helps to lift and balance the top roll while the machine is open. The hinge is made heavy enough so that by the aid of the long lever bar it helps to balance the two rolls; therefore, dropping the hinge raises the adjacent end of the top roll, and simultaneously lowers the opposite end of the bottom roll enough to release the formed plates without disturbing the adjustment of the feed rolls, and closing the hinge brings them automatically back into position for the next plate. If the plates are of different thicknesses it is necessary to adjust the bottom roll accordingly, by means of screws. As the two feed rolls are constantly balanced when the machine is open, the hinge is as easily closed as opened. By reason of the balance produced between the rolls and the hinge, these rolls are practically self-opening, self-closing and self-adjusting.

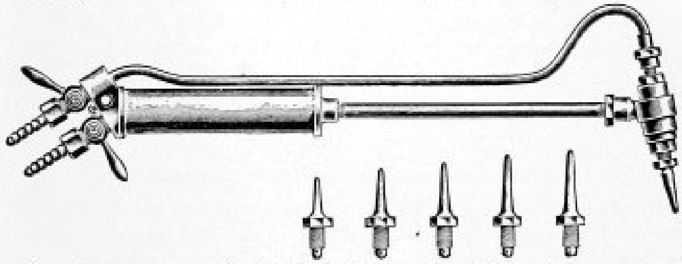
Oxyacetylene Welding Apparatus.

The commercial development of oxyacetylene welding has depended upon the development of cheap methods for producing pure oxygen gas and acetylene gas. The Davis-Bournonville Company, 50 Cliff street, New York, has adopted the chlorate of potash process for generating oxygen as being,



perhaps, the simplest method. The oxygen of chlorate of potash can be driven out by gentle heat and, in practice, the potash is placed in a cold retort and subjected to comparatively low temperature. The reduction is facilitated by the addition of black dioxide of manganese in the proportion of 14 pounds of manganese to 100 pounds of potash. The oxygen gas is passed through scrubbers and is pumped into receivers. The pressure in the receivers is varied according to the use, it being desirable to compress from 125 to 150 pounds per square inch for metal-cutting, while 15 pounds' pressure suffices for autogenous welding.

The acetylene gas is produced in the Davis generator, which is adapted to all pressures up to 15 pounds per square inch. The machine is automatic and feeds lump carbide perfectly up to sizes that pass through 1-inch screen. The theoretical quantity of water to carbide is about ½ pound to 1 pound of carbide, but to absorb the heat of the chemical transformation the generator is required to have a water capacity of one gallon of water to 1 pound of carbide. For work requiring a portable apparatus, the oxygen and acetylene gases are stored in small cylinders. The storage of oxygen is merely a matter of admitting the gas into the cylinders until the required pressure has been reached. The storage of undiluted acetylene under pressure in tanks is impractical. Fortunately, it has been discovered that acetone, a fluid derived from the dry distillation of wood, is a remarkable solvent for acetylene, being capable of absorbing twenty-five times its volume at 60 degrees F. for each atmosphere. At ten atmospheres, or 150 pounds pressure per square inch, a gallon of acetone absorbs 250 gallons of acetylene gas. When absorbed by acetone, the acetylene is non-explosive under heavy pressure, provided there is no free space occupied by the acetylene gas. To prevent the possibility of there being free spaces, the acetylene storage tanks are packed with porous brick, asbestos, or other neutral porous material, thus filling the en-

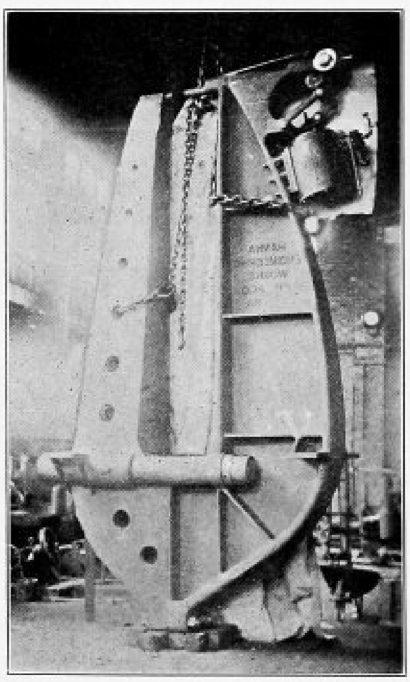


tire free spaces and affording storage for the acetone and acetylene gas only in the cells of the filling.

The Davis-Bournonville Company's cutting and welding torches differ only in the fact that the cutting torch has an auxiliary detachable oxygen tube. The welding torch has simply an acetylene and an oxygen tube, which combines in a tip or nozzle, from which the united gases flow and burn. The enlarged portion of the torch in the acetylene pipe is packed with porous material to prevent flash-backs.

Hanna Round-Stake Plunger Central Compression Yoke Riveter.

Large-sized pneumatic riveters have been made possible by the peculiar Hanna motion, by means of which the action of the machine is made to fulfill the conditions of a hydraulic riveter. The machine illustrated is 126-inch reach by 18-inch

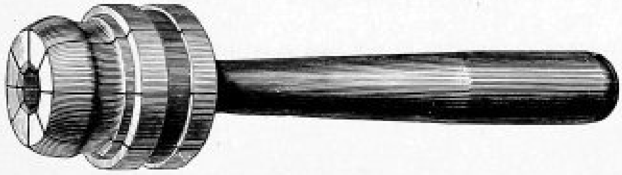


and 24-inch gap, capable of exerting a practically uniform pressure of 80 tons for the last half of the piston travel or ½ inch of die travel with 100 pounds air pressure. On account of this distance, through which a certain known pressure is exerted, there is no necessity for striking the rivet more than once.

The first part of the piston travel, and consequently of the die travel, is accomplished by means of a toggling action, the balance of the toggling action being used in the initial upsetting of the rivet. Since the strain is slight during this stroke in which the moving parts are operating at their greatest speed, the wear and tear is slight. After the toggling action comes a lever action, during which the plates are pulled together and the rivet head formed, but during the lever action the movement of the journals, or bearings, is comparatively slow and slight, entailing very little wear. The fact that with each blow the rivet is set with a pre-determined known tonnage, places this machine in the class with the old reliable hydraulic riveter. The Hanna Engineering Works, Chicago, Ill., are the builders.

The Prosser Boiler Tube Expander.

It seldom happens that a new tool proves so useful that the maker's name comes to be applied to the operation performed by the tool, but such has been the case with the Prosser boiler-tube expander. Thomas Prosser & Son, 24 Platt street,

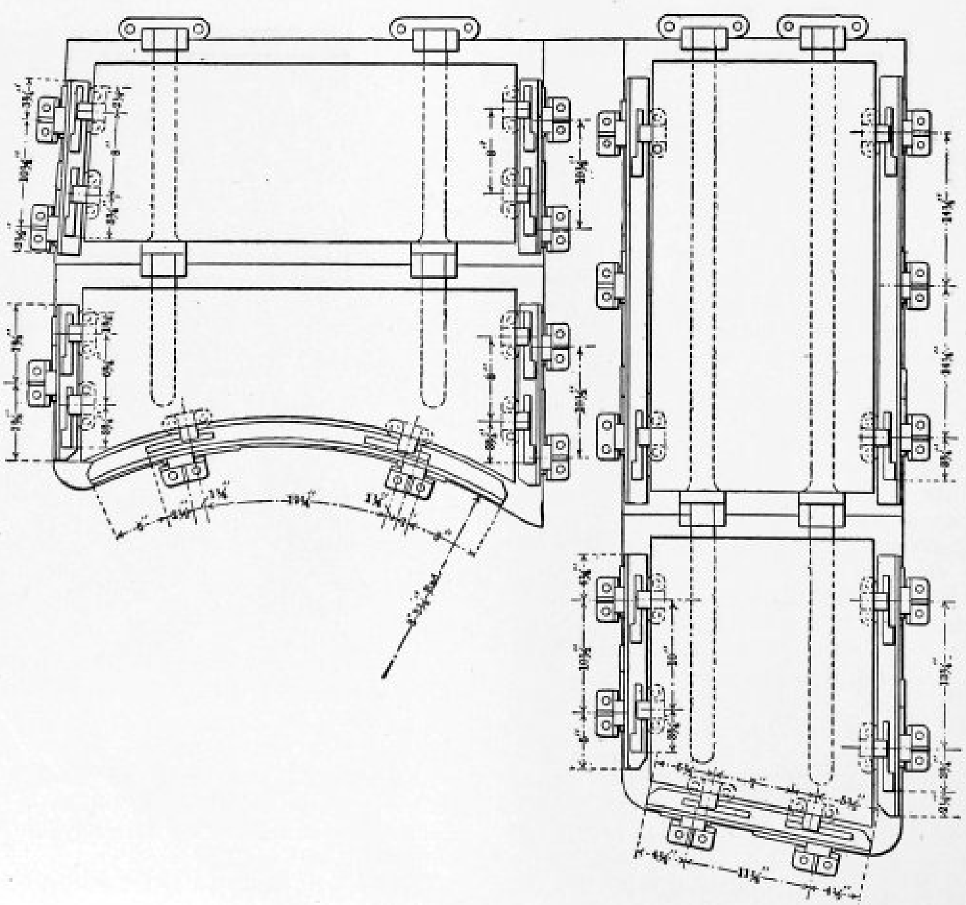


New York, are the original makers of the type of tool known as the Prosser, or sectional expander, a cut of which is shown in the illustration. This tool has been used so extensively, especially in railroad work for the past fifty years, that the operation of expanding flues with a sectional expander is now universally known as "prossering" the tube.

An Airtight Smoke-box Door.

A detailed drawing showing the latest type of Silley's patent smoke-box door, which has just been fitted to the boilers of the American line mail steamer *St. Paul* is shown below. This system of fastening has apparently solved the old trouble with leaky doors. What is claimed for this invention is increased efficiency with both forced and induced draft, increase in economy, and the total stoppage of the continued expense for upkeep charges in straightening buckled doors. These patent smoke-box doors have been running something like two years in some of the large mail ships, including the Cunard liners. At the present time the boilers of the *Mauretania* and the *Lusitania* are being fitted on this system. They are also being fitted in the White Star liner *Adriatic*. It is said that the cost of fitting these smoke-box doors in new installations is little, if anything, in excess of the old style of fitting.

The principle of the fastener is very simple, and consists of angle-iron bars extending the whole length of the three sides of the door. These bars are attached to the door in such a way that they can slide along its edge for a distance of from 3 to 4 inches, the standing leaf of the angle being on the outside edge of the door. Two or more wedge pieces are riveted to the standing leaf of the angle bars, sockets being secured to the smoke-box, into which the wedge pieces will slide on moving the angle bar in a direction parallel with the edge of the door. The effect of this is a wedge action, which forces the angle-iron hard down against the edge of the door, and brings it into close contact with the smoke-box all along its length, the angle-iron bars between the wedges acting as girders, and effectually preventing any possibility of the door's buckling when it becomes unduly heated, which constantly happens with forced draft.



The keeping of smoke-box doors tight may not at first appear a matter of much importance, but every engineer will admit that a leaking door, where natural draft is used, spoils the draft more or less by admitting cold air into the stack and cooling the ascending gases, with the result that it is more difficult to keep steam, the fires require to be worked more, and coal is wasted. With forced draft the result of leaking doors is different. In this case dust and smoke are blown out around the door, this dust covering the boilers and everything in the stokehold. It is even blown into the engine room and up the fidlies, making a very dirty ship. The owners of this invention are the Air-Tight Smoke-Box Door Syndicate. W. C. Wallace, 203 Greenwich street, New York, is the American representative.

SELECTED BOILER PATENTS.

Compiled by
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LOAN AND TRUST BUILDING,
Washington, D. C.

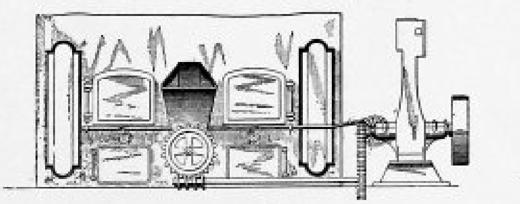
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

896,440. BOILER FURNACE. Burton S. De Ball, of Chicago, Ill.

Claim.—A boiler and its furnace, said furnace including the side walls and a front wall having the usual fuel openings, in combination with a plurality of air-spraying devices forming the portion of said front wall between and upon each side of said openings and forming the side facings thereof, each said device comprising a rectangular box-like member provided with an inwardly extending portion having an arched underface overhanging the grate, a pipe embedded in said front wall above said devices, a short down pipe extending from said pipe into each of said spraying devices and means for supplying air thereto. One claim.

895,764. AUTOMATIC FURNACE. Joel Edgar Jones, of Chicago, Ill., assignor, by direct and mesne assignments, to Jones Automatic Stoker Company, of Chicago.

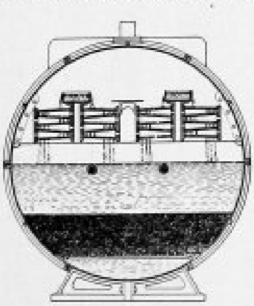
Claim.—The combination of a retort, a conveyor extending into the retort, and a deflector provided with a passageway of substantially the same diameter as the conveyor, said deflector adapted to deflect laterally the material not positively



conveyed through the passageway by the conveyor. Forty-eight claims.

900,323. METHOD OF REDUCING THE CORROSIVE ACTION OF WATER. Frank N. Speller, of Pittsburg, Pa.

Claim.—The method of reducing the corrosive action of water, consisting in feeding the water while heated over suc-



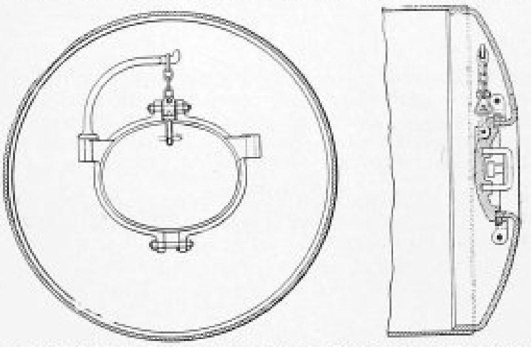
cessive separated bodies of finely divided iron, and then feeding the water into heating systems. Two claims.

900,513. FURNACE. William A. Garvens, of St. Louis, Mo., assignor of one-fourth to John P. McDonough, of St. Louis, Mo.

Claim.—In a furnace having a fire-box and a combustion chamber, an exit flue leading from the combustion chamber, a hollow deflecting wall at the base of the exit flue having an intake opening communicating with the combustion chamber, the furnace being provided at the sides with passageways leading from the chamber of said deflecting wall to the fire-box, said passageways having intake openings disposed along the length thereof for establishing communication between the passageways and the combustion chamber, and an injector for returning a portion of the products from the combustion chamber into the fire-box. Three claims.

900,689. MAN-HEAD CRANE FOR STEAM BOILERS. Sydney Dillon, of Edgewood Park, and John Noey, of Braddock, Pa.

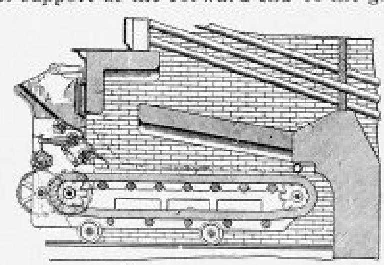
Claim.—A boiler of similar closed vessel having a manhole therein provided with a flanged edge defining its sides, a man-



head, a swinging man-head support and means clamped on the flanged edge of the manhole for securing said support in place. Nine claims.

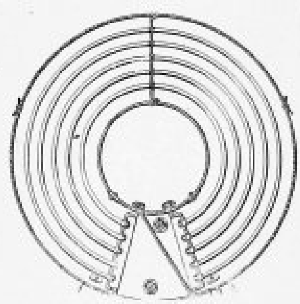
901,038. FURNACE. Herman A. Poppenhusen, of Evanston, and Joseph Harrington, of Chicago, Ill.

Claim.—In a furnace, the combination of a traveling grate having a substantially horizontal fuel-supporting surface, a substantially horizontal deflecting partition extending from the rear end of the furnace forwardly over said grate, to a point near the forward end of the grate, and an inclined, non-aerating fuel support at the forward end of the grate, adapted



to sustain a layer of fuel during a preliminary coking operation, and for the downward movement of said layer thereover by the action of gravity to the forward end of the grate, said fuel support embracing fuel agitating means adapted to maintain the coal in said layer in a fragmentary condition without stirring or mixing the same during the coking operation. Three claims.

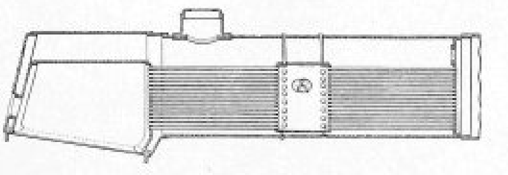
901,245. FEED-WATER HEATER. James H. Kidwell, of Staunton, Va.



Claim.—A water heater for locomotives, comprising an annular shell having a water inlet at one end and a water outlet to the boiler at the other end, steam tubes extending around lengthwise within said shell and connected at one end to the exhaust pipe from the cylinders and at the other end to the exhaust nozzle, and a brace plate extending across the shell intermediate the ends of the tubes, and having holes through which said pipes extend, said brace plate having openings for the circulation of water in the shell. Two claims.

901,291. SMOKE CONSUMER. William M. Grant, of Richmond, Va., assignor of one-half to Michael J. O'Neill, of Manchester, Va.

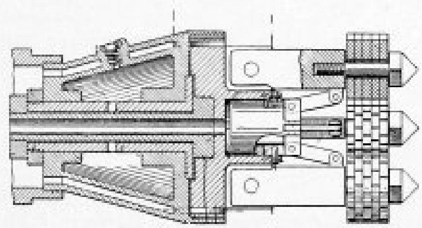
Claim.—In an apparatus of the class described, the combination of a boiler provided with a secondary combustion chamber, formed near its center, said combustion chamber pro-



vided with openings opening into the outer atmosphere in the same horizontal plane and upon opposite sides, means for closing one of said openings, means for directing a forced draft through the other opening, and means for partly closing said last-mentioned opening. Two claims.

901,940. TUBE CLEANER. Thomas Andrews, of Rockaway, N. J., assignor to Thomas Andrews Manufacturing Company, of Rockaway, a corporation of New Jersey.

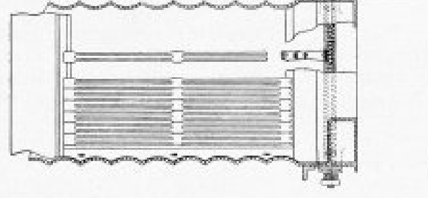
Claim.—A tube cleaner having a head, with an oil chamber therein, a bushing forming a portion of the wall of said oil



chamber and having a perforation therein, thrust-receiving members connected with the ends of said bushing, a shaft extending through said bushing and having thrust-receiving members at the ends thereof, and cleaning devices connected with said shaft. Ten claims.

902,135. FURNACE GRATE AND FIRE-BAR. Richard Campbell, of Liverpool, England.

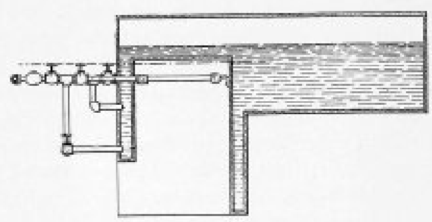
Claim.—In a furnace grate, the combination of a series of independent bars; a tube provided at one end with a lever by which it is can be oscillated, said tube having a longitudinal



slot formed therein; a screw shaft mounted within the tube; an arm mounted upon the screw shaft and projecting through the longitudinal slot in the tube; and means for turning said screw shaft so as to traverse the arm longitudinally and bring it into engagement with one or another of the grate bars. Four claims.

902,208. FEED-WATER HEATER. Luther Henry Caverly, of Somers, Mont.

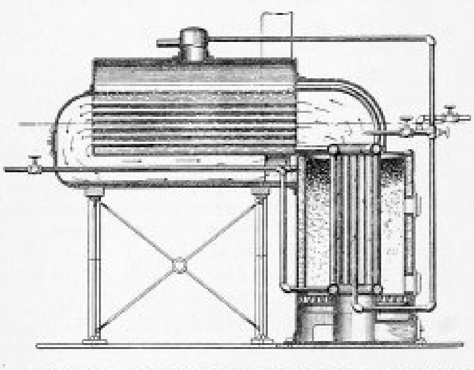
Claim.—The herein described feed-water heater, comprising in combination with a steam boiler having a water space surrounding its fire-box, of a coil-supporting bracket arranged within the fire-box upon one of its walls, the feed-water heating coil arranged in the upper portion of the fire-box and engaged with said bracket, said coil having the horizontal discharge end extending outside of the front of the boiler, then downwardly and then inwardly into the water space of the boiler below the normal level of the water, the controlling valve in said branch or end, said coil also having its inlet end or branch extending outside of the boiler, the branch pipe having the vertical branch depending from said inlet end of the coil and the horizontal branch extending into the water



space of the boiler at a point below the discharge end of the coil, the controlling valve in said branch pipe controlling valves in the inlet pipe of the coil on opposite sides of the branch pipe connection, and the check valve in said inlet end or branch in advance of the valve. One claim.

902,265. BOILER FURNACE. John Ralph Surrell, of New York, N. Y.

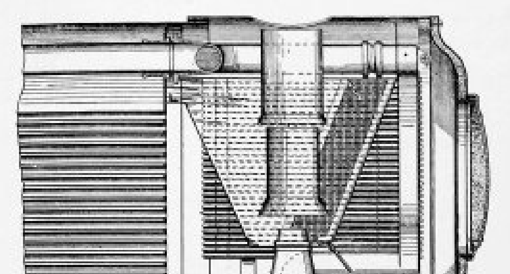
Claim.—A feed-water heater for steam boilers having a water chamber and heating surfaces, said heater comprising a fuel receptacle having grate bars and an ash pit, a set of connected piping mounted within said receptacle with a fuel space surrounding it and forming a chamber for air and gases



within it, means for supplying water to one end of said piping, means connecting the other end of said piping with the water space of the boiler for delivering the heated water thereto, and means placing said chamber in communication with the heating surfaces of said boiler, said piping being vertically disposed within said receptacle and extending from the grate bars to the upper end thereof, and said chamber being open at its upper end. Eight claims.

902,240. SUPERHEATER. Henry B. Oatley, of Schenectady, N. Y., assignor to American Locomotive Company, of New York, a corporation of New York.

Claim.—The combination, with a steam boiler, of a vertical header or casing, supported in the smoke-box adjacent to the front and the side thereof, and comprising separate saturated



and superheated steam compartments, a plurality of loops or bends of superheater pipes, connected, at their opposite ends, to the saturated and the superheated steam compartments, respectively, and extending rearwardly therefrom, a steam supply connection opening into the saturated steam compartment, and a steam delivery connection leading out of the superheated steam compartment. Seven claims.